

NAVIGATION,

THEORY and PRACTICE,

WITH all the necessary TABLES,

To which is added,

Marine Fortification

For the Use of the ROYAL MATHEMATICAL SCHOOL,
CHURCH'S HOSPITAL, and the GENTLEMEN of the NAVY.

IN TWO VOLUMES.

By J. ROBERTSON, F.R.S.
Mathematical Master of Church's Hospital.

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THE
ELEMENTS
OF
NAVIGATION;

CONTAINING THE
THEORY and PRACTICE,

With all the necessary TABLES.

To which is added,

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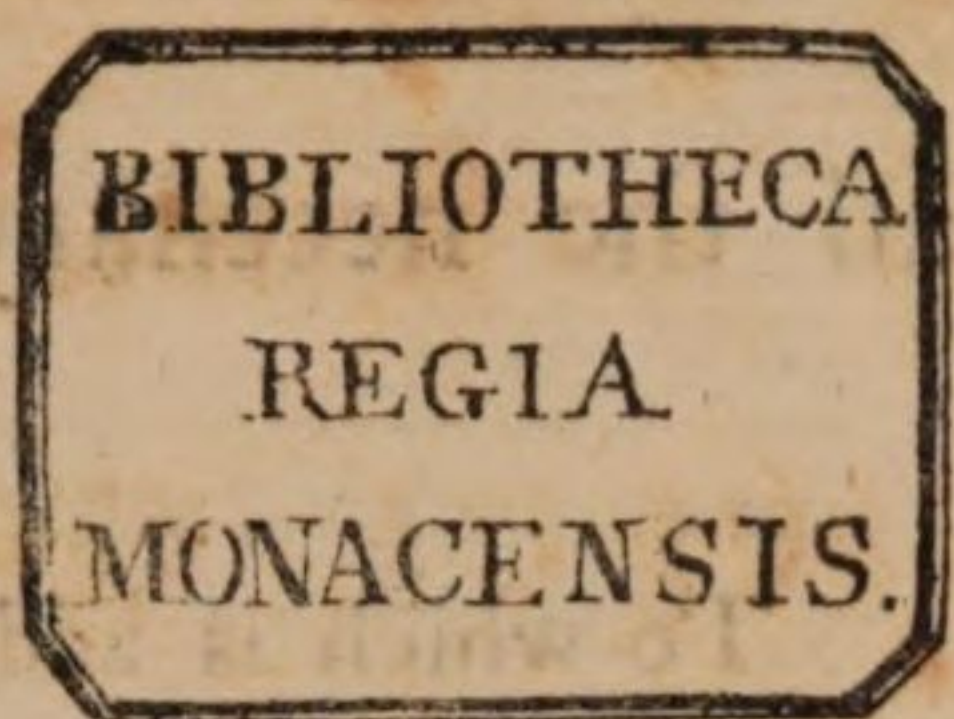
By J. ROBERTSON, F.R.S.
Mathematical Master at CHRIST'S HOSPITAL.

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THE
ELEMENTS

NAVIGATION

THEORY AND PRACTICE



CHAMBERLAIN'S

OF THE ROYAL MATHEMATICAL SCHOOL
AND THE OBSERVATORY OF THE NAVY

TWO VOLUMES

BY J. ROBERTSON, F.R.S.

WITH A NEW METHOD OF CORRECTING THE

LONDON

Printed by J. B. Nichols at the Lane, opposite St. Paul's Church, in the Strand, London.

TO THE
RIGHT WORSHIPFUL
Sir JOHN BARNARD, Knt. Alderman,
PRESIDENT;

THE
Worshipful PHILIP SCARTH, Esq;
TREASURER;

And the rest of the
WORSHIPFUL GOVERNORS
OF
Christ's Hospital, London:

This Book, containing the Elements of Navigation, and a
Treatise on Marine Fortification, composed for the Use of
the Children in the Royal Mathematical School, committed
to my care by your WORSHIPS Favour, is, as a grateful
Acknowledgment, humbly dedicated, by

Your WORSHIPS most humble, and

most obedient Servant,

John Robertson.

TO THE
RIGHT WORSHIPFUL
SIR JOHN BARNARD, Knt. Alderman
P R E S I D E N T

OF THE
WORTHINGTON TRUST
AND THE TRUST
OF THE
WORTHINGTON GOVERNORS
OF THE

Christ's Hospital, London.

This Book containing the Elements of Navigation and a
Treatise on Marine Fortification, compiled for the use of
the Children in the Royal Mathematical School, dedicated
to my Lord by John Worsley's Father, is as a grateful
Acknowledgment, humbly dedicated by

Your Worships most humble, and
most obedient servant

John Robertson.

THE
P R E F A C E.

*I*T having been part of my employment for many years past to instruct youth both in the Theoretical and Practical parts of the art of Navigation, I was naturally led to draw up rules and examples fitted to the years and capacity of the scholar: Some of the precepts have from time to time been altered, according as I had observed how they were comprehended by the majority of my pupils; until at length I had put together a set of materials which I found sufficient for teaching this Art.

Upon my being intrusted by the Governor's of Christ's Hospital with the care of the Royal Mathematical School there, founded by King Charles the Second, I had a great opportunity of experiencing the method I had before used; and finding it fully answered my expectation, I determined to print it for the use of that school: But as those children are to be instructed in the mathematical sciences, on which the art of Navigation is founded, I judged it proper, on their account, to introduce the subjects of Arithmetic, Geometry, Trigonometry, &c.; and for this reason, the title of the Elements of Navigation was chosen whereby to distinguish this treatise.

The ensuing work I have divided into ten Parts or Books, each being a distinct treatise, containing every necessary element which would be wanted in the succeeding articles. The demonstrations of the several propositions are given in as concise a manner as I could contrive, to carry with them a sufficient degree of evidence. Throughout the whole of the elementary parts, I have aimed at brevity and perspicuity; but in the practical parts, have been more full, and, as I apprehend, have included every useful particular worthy the mariner's notice: However, as I am sensible that the most knowing and careful person may overlook slips in his own compositions, which may be discovered by others; therefore, at my request, the greatest part of the manuscript was read and examined by two of my friends, Mr. William Mountaine, F. R. S., and Mr. William Payne, gentlemen well acquainted with the subject of Navigation; who, by their judicious observations, enabled me to improve some articles, for which I esteem myself much obliged to them.

The Reader will find in almost every book a considerable deviation, in point of method, from most authors: In the elementary parts, where it is no easy matter to introduce new Subjects, there will be found, however, the old ones treated of in a manner which, it is apprehended, is better adapted to beginners, and even such new lights thrown on several particulars, as will
render

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render them more easy, than in the view wherein they have been hitherto seen.

The Maritime parts of this work, contained in the VIth, VIIth, and IXth books, are delivered in a manner somewhat different from that of other writers on this subject: Who, for the most part, copying from one another, may be perhaps one reason why the art of Navigation has been so little improved within the last 150 years; for excepting what Norwood and Halley have done, the art seems much in the same state in which Wright left it: However, I apprehend that the proper judges will, from the method I have taken, find some few improvements, if not in the art itself, at least in the manner of communicating it to learners.

The treatise of Fortification annexed to this work, is the result of many years application; and as I thought such a piece might be advantageous to the Gentlemen of the Navy, as well as to the children of the Mathematical School, I judged it would not be unacceptable. In this treatise I have also taken a track very different from what other writers have pursued; for among the multitude which I have seen, they all begin, as near as I can recollect, with the fortifying of a town, the most difficult part of the art, and end with works that are the most easy to contrive and execute: However, I have ventured at beginning with the works of the simplest construction, and proceeded thence, through the different gradations, to the fortifying a town: And although the small limits, to which I have confined myself, have indeed obliged me to be very short in some articles, and totally to omit many others; nevertheless I conceive, that in its present state it may be of considerable use to mariners, and even furnish some hints not altogether unworthy the notice of the Gentlemen of the Army; to whom I may, perhaps, some time hence, present a much larger work on this subject, should this meet with their approbation.

I have always thought, that the chief motives which ought to induce a person to appear as an author, should be, either the having something new to publish, or some new lights to throw on those already published; in either of these cases he cannot be a proper judge, unless he has seen the pieces already extant on that subject; or at least, those of the most eminent authors in the several preceding ages: On this account I was led to examine what had been done by the different writers on the subject of Navigation; and having perused almost every book, wherein that art had been handled, of which I could get information (and I believe few have escaped my enquiry), I drew up for my own amusement an account of those several works; whereby I had an opportunity of discovering the steps by which this art has risen to its present perfection, and consequently, of knowing the most material parts of the history of its progress; and this enabled me, among other things, to rectify one mistake which has crept into most of the modern books of Navigation; which is, that Wright's invention of making a true sea-chart was stolen by Mercator, and published as his own. I suspect this story had its rise from a book printed in the year 1675 by Edward Sherburne, intitled the sphere of Marcus Manilius made an English poem, with annotations and an astronomical appendix.

In

P R E F A C E.

In the catalogue of astronomers, in page 86, the author says: " Mr. EDWARD WRIGHT, contemporary with Mr. Briggs before mentioned, having spent some time in Cambridge, and being naturally addicted to Mathematical Studies, was persuaded to accompany, and went along with the Right Honourable George Earl of Cumberland, in his expedition to the Azores, in the year 1589, on purpose to add the practice of Navigation to the theory; and in the year 1599, he published his book called the Errors in Navigation. A most excellent work for the true describing a sea-chart; which invention of his, Gerardus Mercator published, without owning the author."

Now the fact is, that Gerard Mercator, about the year 1550, published a Map of the world, wherein the degrees of latitude were increased from the equator towards the poles; and hence it was, that charts with the degrees of latitude increasing, were called Mercator's charts. Mr. Wright, it is likely, was born about the year 1560, he being admitted of Caius College, Cambridge, about the year 1582, and about the year 1590, communicated to some acquaintance the principles upon which the degrees of latitude should be increased; and, among others, to Jodocus Hondius, a map-graver, who going to Holland, published the method without the author's consent; and of this Wright complains in the preface to his Errors in Navigation. But before this was published, Mercator died, in the year 1594, and it does not appear that he had done any thing in the latter years of his life; therefore it is not probable that any of Wright's inventions could have been published by Gerard Mercator. Mr. Wright died about the year 1616, and Nicholas Mercator, he who squared the hyperbola about 52 years afterwards, and the person charged by some of the writers on Navigation with the foresaid theft, does not appear to have had any other concerns with Navigation, than the offering to lay a wager about the demonstration of the logarithmic tangents being analogous to the meridional parts: So that the story, intended to assert Wright's invention (which was undoubtedly his own, Mercator's degrees not being increased in their true proportion), contains such a variety of absurdities, as could never have arisen but by trusting to hearsay opinions, originally spread from misconceiving Wright's own account.

I have taken some pains to settle this affair, and hope it will afford entertainment to the curious in these matters, as well as give a caution to those who may hereafter chuse to mention the inventors of the Mercator's chart.

Christ's Hospital,
December 24, 1753.

J. R.

A D V E R.

ADVERTISEMENT.

AS it may be expected that four kinds of readers will look into this book, it was thought convenient to point out to some of them, the places where they may meet with what they more particularly want.

FIRST. Those who having made a proficiency in the mathematics, will, it is likely, examine in what manner the subjects are here treated, and whether any thing new is contained therein: It is conceived that such readers will find some things which may recompence them for their trouble, in almost every one of the books.

SECONDLY. Those learners who are desirous of being instructed in the art of Navigation in a scientific manner, and would chuse to see the reason of the several steps they must take to acquire it: To such persons, it is recommended that they read the whole book in the order they find it: Or, if the learner is very young, he may omit the fourth book till after he is master of the fifth and sixth. Adult persons, and those under the direction of a master, may, if they please, read the VIIIth book immediately after the Vth; and read the VIth, VIIth and IXth books in succession.

THIRDLY. That class of readers, which, with too much truth may be said, comprehends most of our mariners, who want to learn both the Elements and the Art itself by rote, and never trouble themselves about the reason of the rules they work by: As there ever will be many readers of this kind, they may be well accommodated in this work; thus, if they are not already acquainted with Arithmetic and Geometry, let them read the five first rules of Arithmetic, to page 20th; thence proceed to the definitions and problems in Geometry, from page 42 to 55. In the book of Trigonometry, read pages 83, 84, 85, 86, 92, 93, and from 98th to 108th: The whole of book V. In book the VIth he may read to page 267, and as much more as he pleases. In book VII, let him read the sections III, IV, V, VI, from page 368 to page 407. In book VIII he may read section III, and as many problems in the Vth and VIth sections as he can; and let him read the whole of the ninth book.

FOURTHLY. That set of Readers who will not be at the pains of learning any thing more than how to do the practice of a Day's work: Such may herein meet with the practice almost independent of other knowledge. Let such persons make themselves acquainted with section VIII of book V, and the use of the table at page 200; then learn the use of the Traverse table at the end of book VI, which he will find exemplified between pages 243 and 274; also he must learn the use of the Table of meridional parts at page 423: After which, he may proceed to book IX, where he will find ample instructions in all the particulars which enter into a Day's work. But as with this scanty knowledge of things he will not clearly see every part of book IX, he may omit the articles 1059, 1091, 1106, and the XIth and XIIth sections.

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52	6	semicircle	205	35	Anholt 12°			6795
53	7. 9	ca. cb			00' E.	32	8 subdivi-	ons
53	last but 3	draw rs pa-	207	49	C Bon. Esp.			
		rallel to ca			34° 15' S.	373	28	ed for ed
63	9	180°*	208	20	Bridge-T.	397	1	67° 30'
70	16	dele ad		22	59° 50' W.	421	14	2217. 2211
70	last but 4	(249)			Brill 4° 10'	440	15 of	
89	4	s. 25° + s.			East		art. 865	the plane
		35°	209	48	C. Cassander	463	1. 5	VI. 20° 43'
100	28. 29	dele the =s			23° 41' E.	466	30	51° 32'
	30. 31	next the lo-	246	29	33° 13'	468	32	113° 00'
		garithms	258	last but 2	209,9	37. 38	co-alt.	
106	25	$\frac{1}{2} C + D$	259	4	difference	469	22	= $\angle ZPO$
108	13	and on the			(for present)	472	28	10,50860
		other side	260	26	S. 14° 55'	475	39	RP
132	3	that			West	477	29	22° 30'
142	2. 3	CK, ADFB	279	18	lighthouses	503	last	currant
150	11. 24	(2d. 497)	293	37	solution	512	14	40° 38'
153	5	cos. adj. $\angle$	296	8. 32	SW. b. W.	20. 22		9,95185
154	4	cot. m			SE.	23		9,96992

T H E



T H E
E L E M E N T S
O F
N A V I G A T I O N.

B O O K I.
O F A R I T H M E T I C K.

S E C T I O N I.

Definitions and Principles.

1. **A**RITHMETIC is a science which teaches the properties of numbers; and how to compute, or estimate the value of things.

2. An UNIT or UNITY, is any thing considered as one.

3. NUMBER is many units.

4. DIGITS or FIGURES are the marks by which numbers are denoted or expressed, and are the nine following.

Digits,	1.	2.	3.	4.	5.	6.	7.	8.	9.
---------	----	----	----	----	----	----	----	----	----

Names,	One.	Two.	Three.	Four.	Five.	Six.	Seven.	Eight.	Nine.
--------	------	------	--------	-------	-------	------	--------	--------	-------

And with these there is used the mark o, called cypher, which of itself stands for nothing; but being annexed to a digit alters its value.

Thus 40 signifies forty: and 400 stands for four hundred, &c.

5. INTEGER, or WHOLE, NUMBERS, are such as express a number of things, whereof each is considered as an unit.

Thus four pounds, twelve miles, thirty four gallons, one hundred days &c. is in each case called an integer number, or whole number.

6. FRACTIONAL NUMBERS, are such which express the value of some part or parts of an integer unit.

Thus one half, one quarter, three quarters, &c. are each the fractional parts of an unit.

7. **NOTATION** is the expressing by digits or figures any number proposed in words; and the reading of any number that is expressed by figures, is called **NUMERATION**.

8. **DECIMAL NOTATION** is that kind of numbering wherein ten units of any inferior name are equal in value to an unit of the next superior.

9. Every number is said to consist of as many places as it contains figures.

10. The value of every digit in any number is changed according to the place it stands in: and the reading of any number, consists in giving to each figure therein its right name and value.

11. The right hand place of an integer number is called the place of units; and from this place all numbers begin, whether *whole* or *fractional*; the integers increasing in the order from the unit place towards the left; and the fractions decreasing in the order from the unit place towards the right: And to distinguish decimal fractions from integers, there is always a point or comma (,) set on the left hand side of the fractional number; so that the integers stand on the left hand side of the mark, and the fractions on the right hand.

12. For the more convenient reading of numbers, they are divided into periods of six places each, beginning at the unit place: and each period into two degrees of three places each, whose names and order are as follows: Where X stands for the word tens, C for hundreds, and Th. for thousands.

13. Integers												Decimal fractions											
Second period						First period						First period						Second period					
Degree			Degree			Degree			Degree			Degree			Degree			Degree			Degree		
Billions			Th. Millions			Th. Millions			Th. Millions			Th. Millions			Th. Millions			Th. Millions			Th. Millions		
C. X.			C. X.			C. X.			C. X.			C. X.			C. X.			C. X.			C. X.		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		
5			4			3			2			1			2			3			4		

14. RULE, 1st. Suppose the number parted into as many sets or degrees of three places each, beginning at the unit's place, as it will admit of; and if one or two places remain, they will be the units and tens of the next degree.

2^d. Beginning at the left hand, read in each degree, as many hundreds, tens and units, as the figures in those places of the degree express, adding the name thousands, if in the second degree of a period; and adding the name of the period, after reading the hundreds, tens and units in its first degree.

Thus the integer number in the preceding table will be read.

Five billions, four hundred thirty two thousand, one hundred twenty three millions, four hundred fifty six thousand, seven hundred eighty nine.

15. All fractional numbers consist of two parts, which are usually wrote one above the other with a line drawn between them: The number below the line, called the *denominator*, shews into how many equal parts the unit is divided: The number above the line called the *numerator*, shews by how many of these equal parts the value of that fraction is expressed.

Thus 9 pence, is 9 parts in twelve of a shilling; and may be wrote thus $\frac{9}{12}$, when a shilling is the unit.

16. Such fractions whose denominators are 10, or 100, or 1000, or 10000, or 100000, &c. are called *decimal fractions*: But fractions with any other denominators, are called *vulgar fractions*.

The vulgar fractions that most frequently occur, are these.

$\frac{1}{4}$ which is read one fourth or one quarter.

$\frac{1}{3}$ - - - - - one third

$\frac{1}{2}$ - - - - - one half

$\frac{2}{3}$ - - - - - two thirds

$\frac{3}{4}$ - - - - - three fourths, or three quarters.

17. As decimal fractions are parts of an unit divided into either 10, 100, 1000, 10000, &c. parts, according to the places in the fractional number; therefore they are read like whole numbers, only calling them so many parts of 10, or of 100, or of 1000, &c.

Thus a decimal fraction of	{	one two three four &c.	}	places, will be so many parts of	{	10, Ten 100, Hundred 1000, Thousand 10000, Ten thousand &c.	}
-------------------------------	---	------------------------------------	---	-------------------------------------	---	---	---

18. Cyphers on the right hand of integers increase their value; on the left hand of a decimal fraction diminish its value: But on the left hand of integers, or on the right hand of fractions do not alter their value.

Thus $\left\{ \begin{array}{l} 8 \text{ is } 8 \text{ units} \\ 80 \text{ } 8 \text{ tens} \\ 800 \text{ } 8 \text{ hundreds} \end{array} \right\} \text{ And } \left\{ \begin{array}{l} 0, 8 \text{ is } 8 \text{ parts in } 10 \\ 0, 08 \text{ } 8 \text{ parts in } 100 \\ 0, 008 \text{ } 8 \text{ parts in } 1000 \end{array} \right\} \text{ of an unit} \\ \text{so divided.}$

When a fraction has no integer prefixed, it is convenient to put 0 in the place of units.

19. A MIXED NUMBER, is when a fraction is annexed to a whole number.

Thus five and a half is called a mixed number, and is wrote $5 \frac{1}{2}$, or thus 5, 5; which is thus read, five and five tenths.

20. Like names in different numbers, are such figures as stand equally distant from the place of units; or have the same denominations annexed to them.

Thus all numbers of pounds sterling are like names, and so are all numbers of shillings; the like of any numbers of miles, &c.

21. Besides the decimal notation explained in article 8; there are other kinds in common use; such as the *duodecimal*, wherein every superior name contains 12 units of its next inferior name: The *Sexagenary*, or *Sexagesimal*, wherein 60 of an inferior name make one of its next superior. The former is used by workmen in the measuring of artificers works in building; and the latter is used in the division of a *Circle*, and of *Time*.

22. The following characters or marks are frequently used in Arithmetical computations, briefly to express the manner of operation.

The mark $+$ (more) belongs to addition; and shews that the numbers it stands between are to be added together.

Thus $12 + 3$, expresses the sum of 12 and 3; or that 3 is to be added to 12, and is thus read, 12 more 3.

The mark $-$ (less) is for subtraction; and shews that the number following it, or on the right hand, is to be taken from the number preceding it, or on the left hand.

Thus $12 - 3$, expresses the difference between 12 and 3; or that 3 is to be subtracted from 12, and is thus read, 12 less 3.

The mark $\times$ (into) for multiplication, shews that the numbers on each side of it, are to be multiplied the one by the other.

Thus 12×3 , denotes the product of 12 into 3; or that 12 is to be multiplied by 3.

Division is expressed by setting the divisor under the dividend with a line drawn between them, like a fraction.

Thus $\frac{12}{3}$, expresses the quotient of 12 by three; or that 12 is to be divided by 3.

This sign $=$ (equal) shews that the result of the operation by the numbers on one side of it, is equal either to the numbers on the other side, or to the result of the operation by these numbers.

Thus $12 + 3 = 15$; and $12 - 3 = 9$; and $12 \times 3 = 36$; and $\frac{12}{3} = 4$; severally shews the values of the preceding expressions.

TABLES

TABLES of ENGLISH MONEY, WEIGHTS and MEASURES.

MONEY.				TROY WEIGHT.			
Farthings	Pence	Shill.	Pound	Grains	pennywt.	ounces	Pound
960	= 240	= 20	= 1 £	5760	= 240	= 12	= 1 lb.
48	= 12	= 1s		480	= 20	= 1 oz.	
4	= 1d			gr. 24	= 1 dwt.		
<i>Note, 1, 2, 3, farthings are thus wrote</i> $\frac{1}{4}, \frac{1}{2}, \frac{3}{4}.$				<i>Note, Gold and Silver are weighed by</i> Troy Weight.			

AVERDUPOIZE WEIGHT.					WINE MEASURE.				
Drams	Ounces	Pounds	Hund.	Ton	Solid inch	Pints	Gall.	Hogsh.	Pipe Tun
573440	= 35840	= 2240	= 20	= 1	58212	= 2016	= 252	= 4	= 2 = 1
28672	= 1792	= 112	= 1 C		29106	= 1008	= 126	= 2	= 1 P.
256	= 16	= 1 lb			14553	= 504	= 63	= 1 Hhd.	
16	= 1 oz				231	= 8	= 1		
<i>Note, Provisions, Stores &c. are weighed</i> by this.					42 = 1 Tierce 84 = 1 Puncheon				

DRY MEASURE.					CLOTH MEASURES.				
Pints	Gall.	Pecks	Bush.	Quarter	4 Nails	= 1 Quarter of a Yard			
512	= 64	= 32	= 8	= 1	4 Quarters	= 1 Yard.			
64	= 8	= 4	= 1		5 Quarters	= 1 English ell.			
16	= 2	= 1			3 Quarters	= 1 Flemish ell.			
8	= 1				6 Quarters	= 1 French ell.			
<i>Note, 4 bush. = 1 Comb: 10 qrs. = 1</i> Wey, 12 Wey = 1 Last of Corn. 36 Bushels = 1 Chaldron of Coals.									

LONG MEASURE.						
Barly corns	Inches	Feet	Yards	Poles	Furl.	Mile
190080	= 63360	= 5280	= 1760	= 320	= 8	= 1
23760	= 7920	= 660	= 220	= 40	= 1	
594	= 198	= 16½	= 5½	= 1		
108	= 36	= 3	= 1			
36	= 12	= 1				
3	= 1					
Also 3 miles make 1 League. And 20 leagues or 60 Sea miles make a degree. But a degree contains about 69½ miles of statute measure. A Fathom = 6 feet = 2 yards,						

TIME.				
Seconds	Minutes	Hours	Days	Year
31556937	= 525948	= 8766	= 365¼	= 1
86400	= 1440	= 24	= 1 da.	
3600	= 60	= 1 ho.		
60	= 1			

Pence Table.				Even parts of a Pound Sterling.			
Pence	Sh.	Pence	Sh.	Pence	Sh.	Pence	Sh.
20	= 1	8		70	= 5	10	
30	= 2	6		80	= 6	8	
40	= 3	4		90	= 7	6	
50	= 4	2		100	= 8	4	
60	= 5	0		110	= 9	2	

Even parts of a Pound Sterling.				Even parts of a Shilling.			
s	d	is		d	is		
10	0	is ½		6	is ½		
6	8	is ⅓		4	is ⅓		
5	0	is ¼		3	is ¼		
4	0	is ⅕		2	is ⅕		
3	4	is ⅙		1½	is ⅙		
2	6	is ⅙		0¾	is ⅙		
2	0	is ⅙					

SECTION II. ADDITION.

ADDITION is the method of collecting several numbers into one sum.

RULE, 1st. Write the given numbers under each other, so that like names stand under like names; that is, units under units, tens under tens, &c. and under these draw a line.

2^d. Add up the first or right hand upright row, under which write the overplus of the units of the second row, contained in that sum.

3^d. Add these units to the sum of the second row, under which write the overplus of the units of the third row, contained in that sum.

And thus proceed until all the rows are added together.

EXAMPLES.

Ex. I. *Add 28 - - - 76 - - - 47 - - - 18 and 12 together.*

Now the numbers being wrote under each other will stand thus.

28	28
76	76
47	47
18	18
12	12
181	181

Say 2 & 8 is 10, and 7 is 17, and 6 is 23, and 8 is 31; then because 10 units in the right hand row, make an unit in the next row; therefore in 31 there are 3 units of the second row, and an overplus of 1; write down the 1, and add the 3 to the second row, saying; 3 that is carried and 1 is 4, & 1 is 5, and 4 is nine, & 7 is 16, and 2 is 18, in which is one unit of the third row (had there been one) and an overplus of 8; write down the 8, and add the 1 to the third row: But as there is no third row, the 1 carried, must be wrote on the left hand of the 8; and 181 will be the sum of the five given numbers.

Ex. II. *Add 476 - - - 3784 - - - 18329 - - - 290 - - - 75 - - - 7638 - and 46 together.*

476
3784
18329
290
75
7638
46
30638

The Sum

Ex. III. *Add the numbers. 10768 - 3489 - - 28764 - - 289 - - 6438 19 and 438 together.*

10768
3489
28764
289
6438
19
438
50205

The Sum

Ex. IV. *Add these numbers together.*

3720,45
25,0036
4179,802
3,6284
7928,8840

Sum

Ex. V. *Add the following numbers together.*

15836,071
20,09
34,7
583,27008
16474,13108

Sum

In the two last examples, where are integer numbers and fractional numbers, it may be observed, that like integer places, and like fractional places stand under each other; and the manner of adding them together, is the same as explained in the first Example.

25. It frequently happens that numbers are to be added together, whose names do not increase in a tenfold manner as in the last Examples; such as in adding different sums of money, weights or measures; in which, regard is to be had to the number of those of a lower name, contained in one of its next greater name, as shewn in the preceding tables: Examples of which follow.

Ex. VI. *Add the following sums of money together.*

£	s	d
353	14	8 $\frac{1}{2}$
276	10	4
89	17	5 $\frac{1}{4}$
34	12	10 $\frac{3}{4}$
754	15	4 $\frac{1}{2}$

Ex. VII. *Add the following sums of money together.*

£	s	d
7683	08	2 $\frac{3}{4}$
954	19	9 $\frac{1}{2}$
682	10	7 $\frac{3}{4}$
63	15	6 $\frac{1}{4}$
9384	14	2 $\frac{1}{4}$

In these two examples, the carriage is by 4 in the farthings; by 12 in the pence; by 20 in the shillings, and by 10 in the pounds.

Ex. VIII. *Add the following Troy-Weights together.*

lb	oz	dw ^t .	gr.
218	10	13	18
176	9	19	23
85	11	17	11
24	8	15	21
506	5	07	01

Carry for 24, 20, 12 and 10

Ex. IX. *Add the following Averdupoize Weights together.*

Tons	Cwt.	qrs	lb	oz
535	17	3	22	11
94	19	1	27	13
158	12	0	18	15
7	15	2	13	08
797	05	0	26	15

Carry for 16. 28. 4, 20. 10

Ex. X. *Add the following parts of Time together.*

Weeks	Da.	Ho.	Min.	Sec.
21	4	18	37	59
11	6	13	25	47
19	3	23	59	28
38	4	08	22	39
91	5	16	25	53

Carry for 60. 60. 24. 7. 10

Ex. XI. *Add the following parts of a Circle together.*

Deg.	"	"	"	iv
176	32	59	43	25
85	59	27	31	59
114	28	45	59	14
67	12	38	24	47
444	13	51	39	25

Carry for 60. 60. 60. 60. 10.

Explanation of Example VI.

Three farthings and 1 farthing is 4 farthings, and 2 farthings is 6 farthings; which is a penny half penny, set down $\frac{1}{2}$ and carry 1.

Then 1 and 10 is 11, and 5 is 16, and 4 is 20, and 8 is 28 pence; which is 2 shillings and 4 pence; set down 4 and carry 2.

Again 2 and 12 is 14, and 17 is 31, and 10 is 41, and 14 is 55 shillings; which is 2 pound 15 shillings; set down 15 shillings and carry 2 pound. The rest is easy.

SECTION

SECTION III. SUBTRACTION.

SUBTRACTION is the method of taking one number from another, and shewing the remainder, or difference, or excess.

The *subducend* is the number to be subtracted, or taken away.

The *minuend* is the number from which the subducend is to be taken.

RULE, 1st. Under the minuend write the subducend, so that like names stand under like names; and under them draw a line.

2d. Beginning at the right hand side, take each figure in the lower line from the figure standing over it, and write the remainder, or what is left, beneath the line, under that figure.

3d. But if the figure below is greater than that above it, increase the upper figure by as many as are in an unit of the next greater name; from this sum take the figure in the lower line, and write the remainder under it.

4th. To the next name, in the lower line, carry the unit borrowed: And thus proceed to the highest denomination or name.

EXAMPLES.

Ex. I. From 436565874 the minuend.
Take 249853642 the subducend.
Remains 186712232 the difference.

Here the 5 figures on the right of the subducend may be taken from those over them: But the 6th figure viz. 8 cannot be taken from the 5 above it. Now as an unit in the 7th place makes 10 in the 6th place, therefore borrowing this unit makes the 5, 15; then say 8 from 15 leaves 7, which set down; and say 1 carried and 9 is 10, 10 from 6 cannot, but 10 from 16 leaves 6, set it down; then 1 carried and 4 is 5, 5 from 13 leaves 8, set it down: then 1 carried and 2 is 3, 3 from 4 leaves 1.

Ex. II. From 7620908
Take 3875092
Remains 3745816

Ex. III. From 327,9563
Take 49,8697
Remains 278,0866

Ex. IV. From 30007,295
Take 2536,876
Leaves 27470,419

Ex. V. From 5000,
Take 479,6378
Leaves 4520,3622

Ex. VI. Borrowed £ s d
24 14 6 $\frac{1}{2}$
Paid 18 12 4 $\frac{1}{4}$
Remains 6 02 2 $\frac{1}{4}$

Ex. VII. Lent £ s d
294 15 9 $\frac{1}{4}$
Received 89 18 10 $\frac{3}{4}$
Remains 204 16 10 $\frac{1}{2}$

Ex. VIII.

Ex. VIII. In Sexagesimals.

	o	i	ii	iii	iv
From	76	28	37	49	32
Take	65	29	16	53	45
Leaves	10	59	20	55	47

Ex. IX. In Sexagesimals.

	o	i	ii	iii	iv
From	218	46	32	50	18
Take	147	52	47	53	29
Leaves	68	53	44	56	49

27

QUESTIONS to exercise Addition and Subtraction.

QUEST. I. *The share of Jack's prize money was 148*£*. 17*s*. 6*d*. $\frac{1}{2}$; And Tom received as much, beside 7*£*. 18*s*. smart money: How much money did Tom receive?*

	£.	s.	d.
Tom's prize money	148	17	6 $\frac{1}{2}$
smart money	7	18	0
Tom's share	156	15	6 $\frac{1}{2}$

QUEST. II. *The Spanish invasion was in the year 1588, and the French attempted an invasion in the year 1744: How many years were between these fruitless attempts?*

French	1744
Spanish	1588
Years between	156

QUEST. III. *What year was King George born in, he being 67 years old in the year 1749?*

Current year	1749
Age	67
Year born in	1682

QUEST. IV. *Two ships depart from the same port, one having sailed 835 miles, is got 48 miles a-head of the other: Required the aftermost ship's distance?*

The first ship's distance	835
Their difference	48
Second ship's distance	787

QUEST. V. *A seaman who had received 46*£*. 17*s*. 6*d*. for wages, prize money, &c. meeting with bad company was tricked out of 18 guineas: Now John had reckoned to pay his wife's debts of 13*£*. 16*s*. 6*d*. and his landlady's bill of 16*£*. 12*s*. Required whether he can fulfil his intentions, and what will the difference be?*

	£.	s.	d.
Money lost	18	18	0
Wife's debt	13	16	6
Landlady's bill	16	12	0
total	49	6	6
Money received	46	17	6
He will want	2	9	0

QUEST. VI. *Will and Frank talking of their ages in the year 1749: Will said he was born in the year of the Rebellion (in 1715), and Frank said he remembered he was ten years old the year King George the second was crowned (in 1727): Required the age of each, and the difference of their ages?*

Current year	1749
Will was born	1715
Will's age	34
Current year	1749
King George crowned	1727
Years since	22
Frank's age then	10
Frank's age	32

So Will was oldest by two years.

C

SECTION

28 SECTION IV. MULTIPLICATION.

MULTIPLICATION is the method of finding what a given number will amount to, when repeated as many times as is represented by another number.

The number to be multiplied is called the *Multiplicand*.

The number multiplying by, is called the *Multiplier*.

And the number which the multiplication amounts to, is called the *Product*.

Both Multiplicand and Multiplier are called *Factors*.

Before any operation can be performed in Multiplication, 'tis necessary that the learner should commit to memory the following table.

29

The MULTIPLICATION TABLE.

times	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3		9	12	15	18	21	24	27	30	33	36
4			16	20	24	28	32	36	40	44	48
5				25	30	35	40	45	50	55	60
6					36	42	48	54	60	66	72
7						49	56	63	70	77	84
8							64	72	80	88	96
9								81	90	99	108
10									100	110	120
11										121	132
12											144

Observe, that in multiplying any figure in the upper line by any figure in the left hand column, the product will stand right against the figure used in the left hand column, and under that used in the upper line. Thus was 6 to be multiplied by 9, seek the greater figure 9 in the upper line, and right under it, against 6 in the left hand, stands 54 for the Product. And so of others.

The foregoing table being well known, the work of Multiplication will be performed as follows.

To multiply any number, as

By any single figure, as by

37256

7

Set them as in the margin and proceed

260792

thus, 7 times 6 is 42, set down 2 and carry 4; 7 times 5 is 35 and 4 carried is 39, set down 9 and carry 3; 7 times 2 is 14 and 3 carried is 17, set down 7 and carry 1; 7 times 7 is 49 and 1 carried is 50, set down 0 and carry 5; 7 times 3 is 21 and 5 carried is 26, which set down and the work is done. But for compound Multiplication take the following.

30. RULE, 1st. Write the Factors so, that the right hand place of the Multiplier stands under the right hand place of the Multiplicand.

2^d. Multiply the Multiplicand severally by every figure of the Multiplier, setting the first figure of each line under the figure then multiplying by.

3^d. Add the several lines together; and their sum is the Product.

4th. From the right hand of the Product, point off for fractions, as many places as there are fractional places in both Factors; and those to the left of the mark of distinction are integers.

5th.

5th. If the number of places in the Product are not as many as the number of fractional places in both Factors, make up that number by cyphers wrote on the left hand, and to these prefix the mark of distinction.

EXAM. I. *Multiply 742 by 53.*

The lesser Factor being wrote under the greater Factor as here shewn, and a line drawn under them; say 3 times 2 is 6, write 6 under the 3; then 3 times 4 is 12, write down 2 and carry 1; and 3 times 7 is 21, and 1 carried is 22, write the 22:

Multiplicand	742	}	Factors.
Multiplier	53		
		2226	
		3710	
Product		39326	

Again, 5 times 2 is 10, write 0 under the 5, and carry 1; and 5 times 4 is 20 and 1 carried is 21, write down 1 and carry 2; then 5 times 7 is 35, and 2 carried is 37, write down the 37: Now add the two lines together found by multiplying by 3 and by 5, and their sum 39326 is the Product required.

EXAMPLE II.

<i>Multiply</i>	28704
<i>by</i>	8631
	28704
	86112
	172224
	229632
	247744224
	Product.

EXAMPLE III.

<i>Multiply</i>	3684,2795
<i>by</i>	7,594
	147371180
	331585155
	184213975
	257899565
	27078,4185230

Here because there are 4 fractional places in the Multiplicand, and 3 in the Multiplier, which together make 7, therefore 7 places are pointed off on the right of the Product for fractions.

EXAMPLE IV.

<i>Multiply</i>	936,287
<i>by</i>	607,02
	1872574
	65540090
	56177220
	568344,93474

The cyphers in the Multiplier of this example are thus managed. Having multiplied by the 2 as before, say 0 times 7 is 0, write 0 under the 0, and proceed to the next figure 7, by which multiply as before; then coming to the second 0, say 0 times 7 is 0, write 0 under the place of the second 0, and proceed to the next figure 6, by which multiply as before.

C 2

EXAMPLE V.

<i>Multiply</i>	0,34796
<i>by</i>	0,0258
	278368
	173980
	69592
	0,008977368

Here because there are 5 fractional places in one Factor, and 4 in the other, there should be 9 fractional places in the Product; and there arising but 7, therefore 2 cyphers are set on the left hand to make 9 places.

SECTION

SECTION V. DIVISION.

31. *DIVISION* is the method of finding how often one number is contained in another ; or, may be taken from another.

The number to be divided, is called the *Dividend*.

The number dividing by, is called the *Divisor*.

The *Quotient* is the number arising from the division, and shews how many times the Divisor is contained in the Dividend.

The operations in Division are performed as follow.

32. *RULE*, 1st. On the right and left of the Dividend draw a crooked line; write the Divisor on the left side, and the Quotient as it arises, on the right side of the Dividend.

2^d. Seek how often the Divisor may be taken in as many figures on the left hand of the Dividend, as are just necessary ; write the number of times it may be taken, in the Quotient ; and there will be as many figures more in the Quotient, as there are figures remaining in the Dividend then not used.

3^d. Multiply the Divisor by this Quotient-figure, set the Product under that part of the Dividend used ; subtract, and to the right hand of the remainder bring down the next figure of the Dividend : Divide as before ; and thus proceed until all the figures of the Dividend are used.

4th. If there is a Remainder, to its right hand side annex a cypher or cyphers, as if brought down from the Dividend, and divide as before ; and thus it is that fractions arise, *viz.* from the Remainders in Division.

5th When any figure of the Dividend is taken down, or annexed, as before shewn, and the division cannot be taken in the number thus increased ; put 0 in the Quotient, and take down, or annex, another figure ; and proceed in like manner till the Divisor can be taken from the number.

6th. When fractions are concerned : From the number of fractional places used in the Dividend, take those in the Divisor ; count the number of remaining places from the right of the Quotient, put the mark there ; and those to the left are integers, those to the right fractions.

7th. If there arise not so many places in the Quotient as the 6th article requires ; supply the places wanting with cyphers on the left ; and to these prefix the fractional mark.

Ex. I. Divide 3656 £. among 8 persons.

Set the given number as in Art 1st. Now the two left hand figures contain 8 ; then say 8 is contained in 36, 4 times ; set 4 in the Quotient, and say 4 times 8 is 32, set 32 under 36, subtract, there remains 4, to which bring down the next figure of the Dividend 5, makes 45 ; then say 8 is contained in 45, 5 times ; set 5 in the Quotient, and say 5 times 8 is 40 ; write 40 under 45, subtract, and to the Remainder 5, take down 6, the next figure of the Dividend, makes 56 ; then say 8 is contained in 56, 7 times ; write 7 in the Quotient, multiply 8 by 7 makes 56, which wrote under the other 56, and subtracting there remains 0 : So it may be concluded that 3656 contains 8, 457 times : Or if 3656 £. be divided among 8 persons, the share of each would be 457 £.

Ex.

Ex. II. Divide 3125 by 25.

$$\begin{array}{r} 25 \overline{) 3125} \quad (125 \\ \underline{25} \\ 62 \\ \underline{50} \\ 125 \\ \underline{125} \\ 0 \end{array}$$

Ex. III. Divide 95269 by 47.

$$\begin{array}{r} 47 \overline{) 95269} \quad (2027 \\ \underline{94} \\ \text{see precept} \quad 126 \\ \text{5th.} \quad \underline{94} \\ 329 \\ \underline{329} \\ 0 \end{array}$$

Ex. IV. Divide 5859 by 124.

$$\begin{array}{r} 124 \overline{) 5859} \quad (47,25 \\ \underline{496} \\ 899 \\ \underline{868} \\ 310 \text{ for the Remaind.} \\ \underline{248 \text{ see precept 4th.}} \\ 620 \\ \underline{620} \\ 0 \end{array}$$

Ex. V. Divide 337,27368 by 6,28.

$$\begin{array}{r} 6,28 \overline{) 337,27368} \quad (53,706 \\ \underline{3140} \text{ for the Quotient} \\ \text{see precept 6th.} \\ 2327 \\ \underline{1884} \\ 4433 \\ \underline{4396} \\ \text{see precept 5th} \quad 3768 \\ \underline{3768} \\ 0 \end{array}$$

Ex. VI. Divide 2,3569 by 673,4.

$$\begin{array}{r} 673,4 \overline{) 2,3569} \quad (35 \\ 20202 \text{ Quot. } 0,0035 \\ \underline{33670} \text{ see precepts} \\ \underline{33670} \text{ 4th. 6th. 7th} \\ 0 \end{array}$$

In Ex. 6th. the 4 fractional places given in the Dividend, and the 0, used with the Remainder make 5 fractional places; from which 1 place in the Divisor being taken leaves 4 fractional places for the Quotient; but in the Quotient are

only the two places 35, therefore 2 cyphers are prefixed, and makes, ,0035, before which for form sake, an 0 is set for the place of units.

33. When the Divisor does not exceed the number 12, the Division may be performed in one line; by making the Multiplication and Subtraction mentally, or in the mind, and carrying the Remainder, as so many tens, to the next figure.

34. In all operations of Division, it must be observed, that the Product of the Divisor by the Quotient-figure must not exceed that part of the Dividend then using; and the Remainder, by subtracting the Product, must ever be less than the Divisor.

As the Quotient multiplied by the Divisor makes the Dividend;

So the Product of two numbers being divided by one of them, will give the other: that is, Division is proved by Multiplication, and Multiplication is proved by Division.

SECTION VI. REDUCTION.

35. REDUCTION is the method of reducing numbers from one name, or denomination, to another; retaining the same value.

CASE I. To reduce a number consisting of several names, to their least name.

RULE, 1st. Multiply the first, or greater name, by the parts which an unit thereof contains of the next less name; adding to the Product the parts of the second name in the given number.

2d. Multiply this sum by the parts that an unit thereof contains of the next less name; adding to the Product the parts of the third name contained in the given number: And thus proceed, until the least name in the given number is arrived at.

Ex. I. In 23 £. 14 s. 6½ d. how many farthings?

£.	s.	d.
23	14	6½
20		

474 Shillings

12

5694 Pence

4

Answer 22778 Farthings.

Ex. II. In 8 lb. 10 oz. of gold, how many grains?

lb.	oz.
8	10
12	

106 Ounces

20

2120 Pennyweights

24

8480

4240

50880 Grains.

Ex. III. In a cannon weighing 2 Tons, 14 C. 3 qrs. 19 lb. how many pounds?

T.	C.	Qrs.	lb.
2	14	3	19
20			

54 C. weight

4

219 Qrs.

28

1771

438

6151 Pounds.

Ex. IV. In 36 deg. 48'. 27". 56''' how many thirds?

°	'	"	'''
36	48	27	56
60			

2208 Minutes

60

132507 Seconds

60

7950476 Thirds:

An explanation of the first Ex. will make all the rest plain. Since pounds is the greatest name in the given number, and an unit thereof contains 20 of the next less name, or shillings; therefore multiply the pounds by 20, saying 0 times 3 is 0, to which adding the 4 in the 14 s. makes 4; then 2 times 3 is 6, and the 1, in the place of tens in the shillings, make 7; then 2 times 2 is 4: Now multiply 474 s. by 12, saying 12 times

times 4 is 48, and the 6 in the pence make 54, write 4 and carry 5; then 12 times 7 is 84 and 5 is 89 £c. Lastly, multiply the 5694 pence by 4, saying 4 times 4 is 16, and the 2 farthings in the given number is 18, write 8 and carry 1 £c.

36. CASE II. *A number of an inferior name being given; to find how many of each superior denomination are contained therein.*

RULE 1st. Divide the given number, by such a number thereof, as makes one of the next superior name.

2d. Divide this Quotient by the parts making one of the next name.

3d. Divide this Quotient by the parts making one of the next name: And proceed in this manner until the highest name is obtained.

4th. Then the last Quotient, and the several Remainders, will be the parts of the different names contained in the given number.

Ex. I. In 22778 farthings, how many £. S. D.?

$$\begin{array}{r}
 4 \overline{) 22778} \quad 2 \text{ Farthings} \\
 \underline{8} \\
 12 \overline{) 5694} \quad 6 \text{ Pence} \\
 \underline{72} \\
 20 \overline{) 474} \quad 14 \text{ Shillings} \\
 \underline{28} \\
 23 \text{ Pounds.} \\
 \text{Answer } 23 \text{ £. } 14 \text{ s. } 6 \frac{1}{2} \text{ d.}
 \end{array}$$

Ex. III. In 6151 pounds, how many Tons, C. Qrs. lb.?

$$\begin{array}{r}
 28 \overline{) 6151} \quad (219 \\
 \underline{56} \\
 55 \\
 \underline{28} \\
 271 \\
 \underline{252} \\
 19 \text{ Pounds.}
 \end{array}$$

Answer 2 T. 14 C. 3 Qrs. 19 lb.

Ex. II. In 7950476 thirds of a degree, how many ° ' "'''.

$$\begin{array}{r}
 6,0 \overline{) 795047,6} \quad 56 \text{ Thirds} \\
 \underline{60} \\
 6,0 \overline{) 13250,7} \quad 27 \text{ Seconds} \\
 \underline{60} \\
 6,0 \overline{) 220,8} \quad 48 \text{ Minutes} \\
 \underline{60} \\
 36 \text{ Degrees.} \\
 \text{Answer } 36^{\circ}. 48'. 27''. 56'''.
 \end{array}$$

Ex. IV. In 50880 grains, how many lb. oz. dwt. gr.

$$\begin{array}{r}
 24 \overline{) 50880} \quad (2120 \\
 \underline{48} \\
 28 \\
 \underline{24} \\
 48 \\
 \underline{48} \\
 0
 \end{array}$$

Answer 8 lb. 10 oz.

Explanation of Ex. I. Since 4 of the given number, make one of the next name, pence; then 22778 divided by 4, give 5694 pence, and a Remainder of 2 farthings; then 5694 pence divided by 12, the number of pence in one of the next name, shillings, the Quotient is 474 shillings, and a Remainder of 6 pence; then 474 shillings divided by 20, the number of shillings in one of the next name, pounds, the Quotient is 23 pounds, and a Remainder of 14 shillings. And by the 4th precept the answer is collected.

A like operation will solve the other examples, having regard to the increase of the different names.

37. In any Division, if the Divisor has one or more cyphers on the right hand, those cyphers may be pointed off; but then as many places must be pointed off from the Dividend, which places are not to be divided, but reckoned with the Remainder. See the above examples.

CASE

38. CASE III. *To reduce a vulgar fraction to its equivalent decimal fraction.*

RULE. To the Numerator annex one or more cyphers, divide this by the Denominator, and the Quotient will be the fraction sought.

If the Division does not end when six figures are found in the Quotient, the work need not be carried any farther.

EXAM. I. *To reduce $\frac{15}{423}$ to its equal decimal fraction.*

Here 423 the Denominator is made the Divisor, and 15 the Numerator is set for the Dividend, to which annexing a cypher or two for fractional places, seek how often the Divisor can be had in 15 the integral part of the Dividend; and as it cannot be taken, put 0 in the Quotient for the place of units: Then taking in one fractional place, seek how oft the Divisor can be had in 150, say 0 times, and put another 0 in the Quotient for the place of primes: Now taking in two fractional

places to the 15, the Divisor will be contained therein thrice, and thus proceed until the Division ends, or till 6 places arise in the Quotient: But in this example, as the 6th place would be 0, it is omitted, because cyphers on the right hand of decimal fractions are of no signification, as will evidently appear, Notation of Fractions being well understood.

$$\begin{array}{r}
 423 \overline{) 15,00} \quad (0,03546 \\
 \underline{1269} \\
 2310 \\
 \underline{2115} \\
 1950 \\
 \underline{1692} \\
 2580 \\
 \underline{2538} \\
 420
 \end{array}$$

Ex. II. *Reduce $\frac{1}{2}$ to a decimal fraction.*

2) 1,0 (0,5 Answer.

Ex. III. *Reduce $\frac{1}{4}$ to a decimal fraction.*

4) 1,00 (0,25 Answer.

Ex. IV. *Reduce $\frac{3}{4}$ to a decimal fraction.*

4) 3,00 (0,75 Answer.

Ex. V. *Reduce $\frac{5}{8}$ to a decimal fraction.*

8) 5,000 (0,625 Answer.

Ex. VI. *Reduce $\frac{1}{3}$ to a decimal fraction.*

3) 2,00 (0,33 &c. Answer.

Ex. VII. *Reduce $\frac{7}{12}$ to a dec. fraction.*

12) 7,0000 (0,5833 &c. Ans.

In the two last Quotients, it may be observed that 3 would continually arise; such decimal fractions are called circulating or recurring fractions: These have a peculiar kind of operation belonging to them, which the inquisitive reader will find in a little book called *A General Treatise of Mensuration* published in the year 1748; and also in other books.

40. CASE IV. To reduce a number consisting of different names, to a decimal fraction of its greatest name.

RULE, 1st. Write the given names orderly under one another, the least name being uppermost; and on their left side draw a line: Let these be reckoned as Dividends.

2^d. Against each name, on the left hand, write the number making one of its next superior name: And let these be the Divisors to the former Dividends.

3^d. Begin with the upper one, and write the Quotient of each division as fractions, on the right of the Dividend next below it; then let this mixed number be divided by its Divisor, &c.

And the last Quotient will be the fraction sought.

Ex. I. Reduce 15 s. 9³/₄ d. to the fractional part of a pound sterling.

First set the three farthings, the 9 pence, the 15 shillings and 0 pounds under one another; and against the farthings set 4, against the pence set 12, and against the shillings, 20; then the 3, with 0^s. supposed to be annexed, being divided by 4, the Quotient .75 is wrote on the right hand of the 9 pence; and the mixed number 9,75 with 0^s. annexed as they are wanted, being divided by 12, the Quotient .8125 is wrote on the right hand of the 15 s. then this mixed number 15,8125 being divided by 20, the Quotient 0,790625 $\text{\pounds}$. is the answer.

$$\begin{array}{r} 4 \overline{) 3} \\ 12 \overline{) 9,75} \\ 20 \overline{) 15,8125} \\ \underline{0\ 790625} \end{array}$$

Ex. II. Reduce 1 s. 2¹/₄ d. to the fractional part of a pound sterling.

$$\begin{array}{r} 4 \overline{) 1} \\ 12 \overline{) 2,25} \\ 20 \overline{) 1,1875} \\ \underline{0,059375} \end{array}$$

Answer 1 s. 2¹/₄ d. = 0,059375 $\text{\pounds}$.

Ex. III. Reduce 48'. 17". 53^{'''}. to the fractional part of a degree.

$$\begin{array}{r} 60 \overline{) 53} \\ 60 \overline{) 17,883333} \\ 60 \overline{) 48,298055} \\ \underline{0,804967} \end{array}$$

Ans. 48'. 17". 53^{'''}. = 0,804967 Deg.

Ex. IV. Reduce 8 oz. 15 dwt. 18 gr. to the fractional part of a pound troy.

$$\begin{array}{r} 24 \left\{ \begin{array}{l} 4 \overline{) 18} \\ 6 \overline{) 15,75} \end{array} \right. \\ 20 \overline{) 8,7875} \\ 12 \overline{) 0,732291} \end{array}$$

Ans. 8 oz. 15 dwt. 18 gr. = 0,732291 lb.

Ex. V. Reduce 3 qrs. 19 lb. 14 oz. to the fractional part of a C. weight.

$$\begin{array}{r} 16 \left\{ \begin{array}{l} 4 \overline{) 14} \\ 4 \overline{) 19,875} \end{array} \right. \\ 28 \left\{ \begin{array}{l} 4 \overline{) 3,709821} \\ 7 \overline{) 0,927455} \end{array} \right. \\ 4 \overline{) 0,927455} \end{array}$$

Ans. 3 qr. 19 lb. 14 oz. = 0,927455 C.

41. Here because 24 is a number too great to divide by in one line, therefore it is broke into the parts 4 and 6, which multiplied together make 24.

Here the 16 is broke into the numbers 4 and 4; and 28, into 4 and 7; and 14 is divided by 4; and the Quotient 3,5 by 4, &c.

42. CASE V. To reduce a decimal fraction of a superior name, to its value in inferior denominations.

RULE, 1st. Multiply the given fraction by the number that an unit of its name, contains units of the next lesser name; from the right hand of the Product point off as many places as are in the given fraction.

2d. Multiply the places so pointed off, by as many as an unit of this name, contains of the next less name; point off as before.

And thus proceed until the multiplication is made by the least name.

3d. Then the integers, or the numbers on the left of the distinguishing marks in each Product, will be the parts in each name, which together are equal to the given fraction.

Ex. I. What number of shillings, pence, and farthings are equal in value to 0,790625 £. sterling?

Here an unit of the given name £. contains 20 of the next less name shillings, then multiplying by 20, and pointing off 6 places on the right, because the given number 0,790625 contains 6 fractional places, the Product is 15,812500 shillings; then the fractions of this number, viz. 812500 multiplied by 12, the number that an unit of this name contains of the next less name, and the Product pointed as before, there arises 9,750000 pence; the fractions of this number multiplied by 4, gives 3,000000 farthings; then the parts pointed off on the left, viz. 15 s. 9 d. are the value of the given fraction.

$$\begin{array}{r}
 \text{£. } 0,790625 \\
 \underline{20} \\
 \text{s. } 15,812500 \\
 \underline{12} \\
 \text{d. } 9,750000 \\
 \underline{4} \\
 \text{far. } 3,000000
 \end{array}$$

EXAMPLE II. What is the value of 0,056285 £. sterling?

$$\begin{array}{r}
 \text{£. } 0,056285 \\
 \underline{20} \\
 \text{s. } 1,125700 \\
 \underline{12} \\
 \text{d. } 1,5084 \\
 \underline{4} \\
 \text{far. } 2,0336
 \end{array}$$

EXAMPLE IV. What is the value of 0,732291 lb. troy?

This example worked as above by multiplying by 12, 20, 24, the value will be found to be

8 oz. 15 dwt. 18 gr. nearly.

EXAMPLE III. What is the value of 0,58695 degree?

$$\begin{array}{r}
 \text{Deg. } 0,58695 \\
 \underline{60} \\
 \text{Min. } 35,21700 \\
 \underline{60} \\
 \text{Sec. } 13,0200 \\
 \underline{60} \\
 \text{Thirds } 0,120
 \end{array}$$

EXAMPLE V. What is the value of 0,927455 part of a C. weight?

By operating as above, multiplying by 4, 28, 16, the answer will be

3 qrs. 19 lb. 14 oz. nearly.

43 QUESTIONS to exercise the preceding rules.

QUEST. I. *A sloop with the captain and 26 hands take a prize which sold for 1578 £. whereof each seaman had 45 £. and the captain the rest: How much was his share?*

26 Men.
45 £. to each.

130
104

subtract 1170 £. the crew's share
from 1578 £. the whole prize

remains 408 £. the captain's share.

QUEST. III. *A seaman whose wages is 35 s. 6 d. a month, returns home at the end of 29 months; he having taken up 12 £. 18 s.: How much has he to receive?*

s. d.
35 6
mult. by 12

426 pence a month
mult. by 29 months

3834
852

12) 12354 pence.

2,0) 102,9 6d.

from 51 £. 9 s. 6 d. = wages
take 12 £. 18 s. 0 d. received

remains 38 £. 11 s. 6 d. to receive

QUEST. V. *In 306 crowns, how many half crowns and pence?*

Answer { 612 half crowns
18360 pence.

QUEST. VII. *A seaman's share of a prize was 14 guineas, 32 moidores, 12 thirty-six shillings pieces, and 52 pistoles at 17 s. each: How much sterling did the whole come to?*

Answer 123 £. 14 s.

QUEST. II. *A boat's crew of 15 men got by plunder 321 £: How much was the share of each?*

15) 321 (21 £.
30

21
15

remains 6 £. which
mult. by 20 s. in 1 £.

15) 120 s. (8 s.
120

Answer 21 £. 8 s. to each.

QUEST. IV. *Six mess-mates, who propose to live well during an East India voyage of 22 months, agree to expend among them 5 s. a day, besides the ship's allowance: Now one of them having but 25 s. a month, how will matters stand with him at the end of the voyage?*

Now 28 days at 5 s. a day, makes 140 s. or 7 £. a month; which for 22 months, is 154 £.

Then a sixth part of 154 £. is 25 £. 13 s. 4 d. for each man.

Also 25 s. a month for 22 months, makes 27 £. 10 s. for wages; which will over-pay his expences, by 1 £. 16 s. 8 d.

QUEST. VI. *In 30 chalders of coals, each of 36 bushels, how many pecks?*

Answer 4320 pecks.

QUEST. VIII. *Suppose a ship sails 5½ miles an hour for 14 days: How many degrees and minutes has she sailed in the whole; 60 sea miles making one degree?*

Answer 30 deg. 48 min.

SECTION VI. OF PROPORTION.

Or, THE RULE OF THREE.

44. Four numbers are said to be proportional, when by comparing them together by two and two, they either give equal Products or equal Quotients.

Suppose these four numbers 3 8 12 32
In comparing them together by multiplication.

The Product of 3 and 8 is 24; of 12 and 32 is 384, unequal.
of 3 and 12 is 36; of 8 and 32 is 256, unequal.
of 3 and 32 is 96; of 8 and 12 is 96, equal.

Therefore 3 8 12 32, are called proportional numbers.
Now let them be compared together by division.

The Quotient of 8 by 3 is 2,6 &c. of 32 by 12 is 2,6 &c. equal.
of 12 by 3 is 4 of 32 by 8 is 4, equal.
of 32 by 3 is 10,6 &c. of 12 by 8 is 1,5, unequal.

Therefore by this comparison, the numbers are said to be proportional.

In this kind of comparing four numbers together, there is no need to try for more equal Products, or Quotients, than one set of either sort; for either case will determine the proportionality independent of the other.

But it must be observed, that among four proportional numbers, there will be but one set of equal Products; and two sets of equal Quotients, the smaller numbers being Divisors.

45. When four numbers are to be wrote as proportionals, they must be placed in such order, that the Product of the first and fourth be equal to the Product of the second and third.

A question is said to belong to the *Rule of Three*, when three numbers or terms are given to find a fourth proportional, which is the answer to the question.

And in order to resolve such questions, the three given terms must be first placed in a proper order, which is called stating the terms of the question.

46. Questions in the *Rule of Three* are stated, and resolved by the following precepts.

1st. Consider of what kind the fourth term, or number sought will be, whether money, weight, measure, time, &c. and among the three numbers given in the question, let that which is of the same kind with what is required, be placed for the third term.

2. From the nature of the question, determine whether the number sought will be greater or less than the number which is placed for the third term.

3d. If the fourth term will be greater than the third, set the greater of the remaining two terms for the second, and the lesser for the first.

But if the fourth term is to be less than the third, set the greater of the remaining two terms for the first, and the lesser for the second.

Then in either case, the given three terms are stated.

4th. Reduce those terms which consist of more names than one, to one name; and observe that the first and second terms are always to be of the same name.

5. Multiply the second and third terms together, divide the Product by the first term, and the Quotient will be the fourth term, of the same name the third term was reduced to.

47. QUEST. I. *If 4 yards of cloth cost 18 s. what will 24 yards cost?*

Here it is plain, that the term sought or the worth of 24 yards, will be money; therefore the given money 18 s. is set for the third term; and as the worth of 24 yards must be greater than the worth of 4 yards, therefore the 24 is set for the 2d. term, and the 4 for the 1st. Then the 2d. term 24 being multiplied by the 3d. 18, the Product is 432, which divided by the 1st. term 4, the Quotient or 4th term is 108, which are shillings, the same name of the 3d. term; then 108 shillings divided by 20, gives 5 £. 8 s.

yds.	yds.	s.
4	24	18
	18	
	192	
	24	
	4) 432	(108 shillings.
	2,0)	10,8 shillings.
		5 Pounds.
	Answer 5 £. 8 s.	

QUEST. II. *If I lend 200 £. for 12 months, how long ought I to have the use of 150 £. to recompence me?*

Here the answer or 4th term is to be time; therefore let 12 months, the given time, be set for the 3d. term: Now it is evident that the 150 £. being less than the 200 £. must be kept a longer time, and so the 4th term will be greater than the 3d. term: Therefore the 200 is put for the 2d. term, and the 150 for the 1st. Then the 2d. term multiplied by the 3d. the Product will be 2400; which being divided by the 1st. term, the Quotient 16 is the 4th term; and because the 3d. term was months, the 4th term will be months.

£.	£.	m.
150	200	12
	12	
	15,0)	240,0 (16 months.
	15	
	90	
	90	
	Answer 16 months.	

QUEST.

QUEST. III. *What will 1836 lb. of raisins come to, at the rate of 6 s. 8 d. for 24 lb.*

Here as money is the thing sought, money must be the 3d. term: And as 6 s. 8 d. consists of two names, they must be reduced to one name, viz. pence.

lb.	lb.	s.	d.
24	1836	6	8
		6	8
	1836	12	
	80	—	
	—	80	pence
24)	146880	(6120	pence
	144		
	—	12)	6120
	28		
	24	2,0)	51,0 10 s.
	—		25 £.
	48		
	48		
	—		
	00		

Here the 2d. term being multiplied by the 3d. and the Product divided by the 1st. the Quotient is 6120 pence; which being valued gives 25 £. 10 s.

QUEST. IV. *If 20 yards of cloth 5 quarters wide will serve to hang a room: How many yards of 4 quarters wide will serve to hang the same room?*

Here yards of length are required; then 20 yards must be the 3d. term.

qrs.	qrs.	yds.
4	5	20
		5
		—
		4) 100 (

Answer 25 yards.

48. As it will be more convenient in most cases to reduce such numbers or terms which consist of several names to the fractional parts of their greatest name, than to reduce them to their lowest name; therefore in the solution of some of the following questions, the inferior parts of the given terms, are reduced by case IV. of Reduction; and the answers are valued by case V.

QUEST. V. *What will 420 yards of cloth come to at 14 s. 10 $\frac{3}{4}$ d. for 1 ell english?*

The term sought being money, the 14 s. 10 $\frac{3}{4}$ d. must be the 3d. term, and be reduced to farthings: Also the 1st. and 2d. terms are to be reduced to quarters of yard.

Ell Eng.	yds.	s.	d.
1	420	14	10 $\frac{3}{4}$
1	420	14	10 $\frac{3}{4}$
5	4	12	
5	1680	178	
	715	4	
	—	715	farth.

8400	
1680	
11760	
5) 1201200 (	
4) 240240	farthings
12) 60060	pence
2,0) 500,5	05 s.
250	£.

Answer 250 £. 5 s.

The Divisor 5 being a single digit, the Quot. is wrote under the Div.

QUEST. VI. *A owes to B 463 £. but compounds for 7 s. 6 d. in the pound: How much must B receive for his debt?*

Here composition money is the thing sought; then the 3d. term must be the composition money, viz. 7 s. 6 d.

£.	£.	s.	d.
1	463	7	6
	00	12	
12)	41670	6 d.	90 pence
2,0)	347,2	12 s.	
	173		

Answer 173 £. 12 s. 6 d.

QUEST.

QUEST. VII. If 8 lb. of pepper cost 4s. 8 d. What will 7 C. 3 qrs. 14 lb. come to at that rate?

lb.	C.	qrs.	lb.	s.	d.
8	7	3	14	4	8
	4			12	
	—			—	
	31			56	
	28			882 lb.	
	262			56	
	62			5292	
	882			4410	
	—			—	
			8)	49392 (	
			12)	6174 6d	
			2,0)	51,4 14s	
				25 £.	

Answer 25 £. 14 s. 6 d.

QUEST. IX. What is the interest of 584 £. for a year, at 5 per cent. per annum: Or at the rate of 5 £. for the use of 100 £. for a year?

Here interest is the term required: therefore 5 £. the interest of 100 £. is to be the 3d. term: And as the 4th term, or the interest of 584 £. is greater than the 3d. term; then the 2d. term is to be greater than the 1st.

£.	£.	£.
100	584	5
	5	
1,00)	29,20 (	See Case V. of Reduction.
	20	
	4,00	

Answer 29 £. 4 s.

QUEST. XI. What is the interest of 542 £. 10 s. for 219 days, at 5 £. per cent. per annum?

To solve this question, find the interest for 1 year; multiply this interest by 219 and divide the Product by 365, the Quotient will be the answer; and is 16 £. 5 s. 6 d.

QUEST. VIII. One bought 4 Hhds. of sugar, each containing 6 C. 2 qrs. 14 lb. at 2 £. 8 s. 6 d. for each C. weight: What did the whole come to?

C.	C.	qrs.	lb.	£.	s.	d.
1	6	2	14	2	8	6

Now 1 C. weight is 112 lb.
And 4 Hh. at 6 C. 2 q. 14 b. = 2968 lb.
Also 2 £. 8 s. 6 d. is 582 d.
Then the Product of the 2d. and 3d. terms is 1727376.
Which divided by the 1st. term 112, the Quotient is 15423 pence, whose value is 64 £. 5 s. 3 d.

QUEST. X. What is the interest of 387 £. 12 s. for 3 years and 4 months, at 3½ per cent. per annum?

Find the interest for 1 year; then thrice that, together with ⅓ of one year, will be the interest sought.

£.	£.	£.
100	387,6	3,5
	3,5	
	19380	
	11628	
100)	1356.60 (	
	£. 13,566 for 1 year.	
	3	

40,698 for 3 years
⅓ of 1 year = 4,522 for 4 months.
45,220

Answer 45 £. 4 s. 5 d.

QUEST. XII. For how long must 487 £. 10 s. be at simple interest at 4½ £. per cent. per annum, to gain 95 £. 1 s. 3 d.?

Find what will be the interest of 487 £. 10 s. for 1 year; divide 95 £. 1 s. 3 d. by this interest, and the Quotient will be 4 years.

QUEST.

QUEST. XIII. One bought 14 pipes of wine, and is allowed 6 months credit: But for ready money gets it 6 d. in a gallon cheaper: How much did he save by paying of ready money?

Answer 44 £. 2 s.

QUEST. XV. One bought 3 tons of oyl for 153 £. 9 s. which having leaked 74 gallons, he would make the prime-cost of the remainder: How must it be sold per gallon?

Now 1 T. = 252 Gall. And 3 T. = 756
Subtract the gallons leaked = 74

Remains 682

G.	£.	G.
Then 682	153,45	1
Answer 4 s. 6 d. a gallon.		

QUEST. XVII. At 13 £. for 100 lb. of goods: What will 895 lb. come to allowing 4 lb. upon every 100 lb. for tret, or waste?

Since 4 lb. is to be allowed on the 100 lb. therefore 104 lb. is given for 100.

lb.	lb.	£.
Then 104	895	13
Answer 111 £. 17 s. 6 d.		

QUEST. XIX. If 100 pounds of sugar be worth 36 s. 8 d.: What will be the worth of 875 lb. rebating 4 lb. upon every 100 lb. for tare?

Here the buyer has 100 lb. on paying for 96 lb.

lb.	lb.	lb.
Then 100	96	875
And the 4th term will be 840 lb.		

lb.	lb.	£.
Also 100	840	1,833333

Then the 4th term will be 15 £. 8 s. and so much will the sugar come to.

QUEST. XIV. A clothier sold 50 pieces of Kersey, each piece containing 34 ells Flemish, at the rate of 8 s. 4 d. per ell English: What did the whole come to?

Answer 425 £.

QUEST. XVI. A broker sold $\frac{2}{3}$ of $\frac{1}{4}$ of a ship for 147 £. 11 s. 3 d.: How much was the whole ship valued at?

Now $\frac{2}{3}$ of $\frac{1}{4}$ = $\frac{6}{10}$ = 0,3.

And 147 £. 11 s. 3 d.	=	147,5625 £.
share	share	£.
Then 0,3	1	147,5625

Answer 491 £. 17 s. 6 d.

QUEST. XVIII. One has cloth which cost 2 s. 8 d. a yard: For how much must it be sold a yard on 3 months credit, to gain 25 £. per cent. per annum?

mon.	mon.	£.	£.
First 12	3	25	6,25
	£.	£.	£.
Secondly 100	6,25	0,133333	
By multiplying and dividing, the 4th term will be found 2 d.			
Then 2 s. 8 d. + 2 d. = 2 s. 10 d. a yard the selling price.			

QUEST. XX. A chapman bought 81 Kerseys for 135 £. How must he sell them per piece to gain 15 £. per cent.?

Find how much 135 £. will be advanced to at 15 £. per cent.

Then this sum divided by 81 will be the selling price of each piece.

£.	£.	£.	£.
Now 100	115	135	155,25.
Then 81	155,25	(1,916666)	£.
Answer 1 £. 18 s. 4 d. a piece.			

QUEST.

QUEST. XXI. *A merchant who is to receive a sum of money, is offered ducats at 6 s. 4 d. which are worth but 6 s. 2½ d. or chequins at 8 s. 2 d. each, that are worth but 8 s. By which specie will he sustain the least loss?*

6 s. 2½ d.	= 74,5 d.	} the real value.
8 s. 0	= 96	
6 s. 4	= 76 d.	} the advan. val.
8 s. 2 d.	= 98	

r. val.	r. val.	ad. va.	ad. va.
Then 74,5	96	76	97,93.

But the chequins are valued at 98 d. Therefore the ducats are most advantageous.

QUEST. XXIII. *A person wants 750 pieces of foreign coin, each worth 11 s. 4 d. How much will they come to, allowing the broker the worth of 2 pieces upon every 100?*

Now 100	102	750	765
---------	-----	-----	-----

He must pay for 765 pieces, which will come to 433 £. 10 s.

QUEST. XXV. *A grocer bought 4¼ C. of pepper for 15 £. 17 s. 4 d. which proving to be damaged he is willing to lose 12½ £. per cent. For how much must he sell it a lb.?*

Since he is to lose 12½ per cent. he must take 87 £. 10 s. for 100 £. Now diminish the 15 £. 17 s. 4 d. in this proportion, and this sum divided by the pounds in 4¼ C. will give 7 d. for what each pound is to be sold at.

QUEST. XXII. *One who had sold a parcel of cloths at 2 s. 10 d. a yard on 3 months credit, found he had gained 25 £. per cent. per annum: What did the cloth cost per yard?*

	mo.	£.	mo.	£.
Now	12	25	3	6,25
And	100	+	6,25	= 106,25 £.

	£.	£.	£.
Then	106,25	100	0,14166

The fourth term to which will be a fraction whose value will be 2 s. 8 d. which is the prime-cost per yard of the cloth.

QUEST. XXIV. *A gentleman would exchange 729 pieces of 4 s. 2 d. each into sterling money: How much will he receive for them, allowing the broker 1¼ £. per cent.?*

	P.	P.	£.	£.
Now	1	729	0,208333	151,875

the worth of the pieces.
Then 101,25 100 151,875 150 £.
He will receive 150 £. for them.

QUEST. XXVI. *Suppose 42 gallons of honey be valued at 2 £. and the duty is 15 £. per cent. on this value, and a draw back of 5 £. per cent. on the duty for prompt payment: What will the ready money duty of 672 gallons come to?*

Now	42	2	672	32 £.
And	100	15	32	4,8 £.
Also	100	95	4,8	4,56 £.

Answer 4 £. 11 s. 2½ d.

The Rule of Proportion is of almost universal use in all business where computation is required; as in buying and selling; values of stocks and their dividends; the interest and discount of money; the customs and duties on goods &c. But the designed brevity of this book will not permit farther illustrations.

SECTION VII. OF THE POWERS OF NUMBERS AND OF THEIR ROOTS.

49. *The POWER of a number, is a product arising by multiplying that number by itself, the product by the same number, this product by the same number, &c. to any number of multiplications.*

The given number is called the first power, or root.

The Product of the 1st. power by itself, is the 2d. power, or square.

The Product of the 2d. power by the 1st. is the 3d. power, or cube.

The Product of the 3d. power by the 1st. is the 4th. power, &c.

50. Here follows the 1st. 2d. and 3d. powers of the nine digits.

Roots, or 1st. power	1	2	3	4	5	6	7	8	9
Squares, or 2d. power	1	4	9	16	25	36	49	64	81
Cubes, or 3d. power	1	8	27	64	125	216	343	512	729

Ex. I. *What is the 2d. power, or square of the number 24?*

$24 \times 24 = 576$ is the 2d. power.

Ex. II. *What is the 3d. power, or cube of 38?*

Now $38 \times 38 = 1444$ the 2d. power.

Then $1444 \times 38 = 54872$ the 3d. power.

51. The figure shewing the name of any power, is called the index of that power.

Thus 1 is the index of the 1st. power; 2 is the index of the 2d. power; 3 of the 3d. power, &c.

52. Any number may be considered as a power of some other number.

Thus 64 may be taken as the 2d. power of 8, and the 3d. power of 4, &c.

53. The root of a given number considered as a power, is a number which being raised to the index of that power, will either be equal to the given number, or approach very near to it.

54. *To extract the Square Root of a given number.*

1st. Begin at the unit's place, put a point over it, and also over every next figure but one, reckoning to the left for integers, and to the right for fractions; and there will be as many integer places in the root, as there are points over the integers in the given number.

The figure under a point, with its left hand place, is called a period.

2d. Under the left hand period write the greatest square contained in it, and set the root thereof in the Quotient; subtract the square, and to the remainder bring down the next period, as in Division.

3d. On the left of this Remainder write the double of the Root or Quotient for a Divisor; seek how often this may be had in the Remainder, except the right hand place; write what arises both in the Root, and on the right of the Divisor.

4th. Multiply this increased Divisor by the last Quotient figure; subtract, and to the Remainder bring down the next period; double the Root for a Divisor, and proceed as before.

55. Fractional places will arise in the Root by annexing to the Remainders, periods of two cyphers each, and renewing the operation.

Ex.

Ex. I. *What is the Square Root of 1444?*

Put a point over the units place 4, and also over the place of 100s. Now the number consists of 2 periods, and will have 2 integer places in the Root: Then the greatest Square in 14, the left hand period, is 9, and its Root is 3; write 9 under the period, and 3 in the Root; now 9

from 14 leaves 5, to which annex the next period 44; the Root 3 doubled makes 6, which in 54 is contained 8 times, annex 8 to the 3 and to the 6, makes the Root 38 and the Divisor 68; then 8 times 68 is 544; and there remaining 0 on subtraction, it may be concluded that 38 is the true Root.

$$\begin{array}{r} \cdot \cdot \\ 1444 \text{ (38 Root.} \\ 9 \\ \hline 68) \ 544 \\ \underline{544} \end{array}$$

Ex. II. *What is the Square Root of 36372961?*

$$\begin{array}{r} \cdot \cdot \cdot \cdot \\ 36372961 \text{ (6031 Root.} \\ 36 \\ \hline 1203) \ 3729 \\ \underline{3609} \\ 12061) \ 12061 \\ \underline{12061} \end{array}$$

Ex. IV. *What is the Square Root of 24681024?*
Answer 4968.

Ex. VI. *What is the Square Root of 76395820?*

$$\begin{array}{r} \cdot \cdot \cdot \cdot \cdot \cdot \\ 76395820 \text{ (8740,4702} \\ 64 \\ \hline 167) \ 1239 \\ \underline{1169} \\ 1744) \ 7058 \\ \underline{6976} \\ 174804) \ 822000 \\ \underline{699216} \\ 1748087) \ 12278400 \\ \underline{12236609} \\ 174809402) \ 417910000 \\ \underline{349618804} \\ 68291196 \end{array}$$

Ex. III. *What is the Square Root of 1,0609?*

$$\begin{array}{r} \cdot \cdot \cdot \\ 1,0609 \text{ (1,03 Root.} \\ 1 \\ \hline 203) \ 0609 \\ \underline{609} \end{array}$$

Ex. V. *What is the Square Root of 911236798,794365?*
Answer 30186,699.

In the 6th example, after all the periods given were brought down, there remained 8220, to which a period of two cyphers was annexed, and the operation renewed, and continued until 4 decimal places were obtained in the Root; every period brought down giving one place.

RULE, 1st. Over the unit place of the given number put a point, and also over every third figure from the unit place, to the left for integers, and to the right for fractions; and the Root will have as many integer places, as there are points, or periods, in the integral part of the given number.

2d. Under the left hand period, write the greatest Cube it contains, whose Root set in the Quotient: Subtract the Cube from the period, and to the Remainder annex the remaining periods; call this the Resolvend.

3d. To the Quotient annex as many cyphers as there were periods remaining; call this the Root.

4th. Divide the Resolvend by the Root, add the Quotient to thrice the Square of the Root, let the sum be a Divisor to the Resolvend, and the Quotient figures annexed to the right of the first Root, without the cyphers, will be the Cube Root sought.

5th. If the second figure of the Root be 1, or 0; then generally 3 or 4 figures of the Root will be obtained at the first operation: But if the second figure exceeds 2, it will be best to find only two places at first.

6th. To renew the operation; subtract the Cube of the figures found in the Root, from the given number; then form a Divisor and divide as directed in the 4th precept; and this will give the Root true to 5 or 6 places: For each operation commonly triples the figures found in the last Root.

Ex. I. *What is the Cube Root of 9800344?*

Put a point over the unit place 4, another over the place of thousands, and another over that of millions; and because there are 3 points, there will be 3 places in the Root. Under the left hand period 9, write 8 the greatest Cube therein, and its Root 2, write in the Quotient, then subtracting, the Resolvend is 1800344: Now because there are two periods remaining, therefore two cyphers annexed to the Root 2, makes it 200, by which dividing the Resolvend, the Quotient is 9001; also the square of 200 is 40000, the triple thereof 120000 being added to 9001, makes 129001 for a Divisor, by which dividing 1800344, the Quotient is 14 nearly, and is taken as 14 because it is much nearer to it than to 13; now 14 being annexed to the former Root 2, makes 214 the Root sought. For $214 \times 214 \times 214 = 9800344$.

$$\begin{array}{r}
 \begin{array}{r}
 \cdot \\
 \cdot \\
 \cdot \\
 9800344 \quad (2 \\
 \underline{8} \\
 2,00)18003,44 \text{ Resolvend.} \\
 \underline{18000} \\
 9001 = \text{Quotient.} \\
 120000 = \text{thrice the Sq. of the R.} \\
 \underline{129001} \quad 1800344 \quad (14 \\
 129001 \\
 \hline
 510334 \\
 516004
 \end{array}
 \end{array}$$

The Root is 214

Ex. II.

Ex. II. *What is the Cube Root of 518749442875?*

$$\begin{array}{r}
 518749442875 \text{ (8)} \\
 \underline{512} \\
 8,000) 6749442.875 \\
 \underline{843680} \\
 192000000 \\
 \underline{192843680} \quad 6749442875 \text{ (035)} \\
 \underline{578531040} \\
 964132475 \\
 \underline{964218400}
 \end{array}$$

In this example, because 3 periods were remaining, and consequently 3 places more to be found; therefore in the last division a point is put over the 3d. place from the right hand, and the Divisor is first to be tried in the Dividend as far as this point, in which as it cannot be taken, 0 is put in the Quotient, &c. here the last figure 5 is too much, but it is much nearer to 5 than to 4; then 035 annexed to the first Root 8, makes 8035 for the Root.

Ex. III. *What is the Cube Root of 114604290,028?*

$$\begin{array}{r}
 114604290,028 \text{ (4)} \\
 \underline{64} \\
 4,00) 50604290 \\
 \underline{126510} \\
 480000 \\
 \underline{606510} \quad 50604290 \text{ (8)}
 \end{array}$$

Here 480 is taken for the Root at the first operation.

Then 114604290,028 (48

110592

$$480) 4012290$$

8358,9 the Quotient.
691200 = triple the Square of 480.

Divisor 699558,9) 4012290,028 (5736

$$\underline{34977945}$$

$$\begin{array}{r}
 5144955 \\
 4896912
 \end{array}$$

$$\begin{array}{r}
 248043 \\
 209867
 \end{array}$$

$$\underline{38176}$$

To 480 the first Root

Add 5,736

Sum 485,736

57. Here instead of bringing down the figures of the Dividend to the Remainders, the Divisor is lessened each time by pointing off a place on the right; but regard is to be had to the carriage which will arise from the places thus omitted.

SECTION

SECTION VIII. OF NUMERAL SERIES.

58. A rank of three or more numbers that increase or decrease by an uniform progression, is called a Numeral Series.

59. If the Progression is made by equal differences, that is by the constant addition or subtraction of the same number; the series is called an *Arithmetic Progression*.

Thus $\left\{ \begin{array}{l} 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \text{ } \& c. \text{ increasing by adding } 1. \\ 3 \quad 6 \quad 9 \quad 12 \quad 15 \quad 18 \quad 21 \quad 24 \quad 27 \text{ } \& c. \text{ increasing by adding } 3. \\ 49 \quad 43 \quad 37 \quad 31 \quad 25 \quad 19 \quad 13 \quad 7 \quad 1 \text{ } \& c. \text{ decreasing by subtracting } 6. \end{array} \right.$

are ranks of numbers in Arithmetic Progression; and of such ranks there may be an infinite variety.

60. If the Progression is made by a constant multiplication or division with the same number, the series is called a *Geometric Progression*.

Thus $\left\{ \begin{array}{l} 1 \quad 2 \quad 4 \quad 8 \quad 16 \quad 32 \quad 64 \text{ } \& c. \text{ increasing by } 2 \\ 1 \quad 5 \quad 25 \quad 125 \quad 625 \quad 3125 \quad 15625 \text{ } \& c. \text{ increasing by } 5 \\ 6561 \quad 2187 \quad 729 \quad 243 \quad 81 \quad 27 \quad 9 \quad 3 \text{ } \& c. \text{ decreasing by } 3 \\ 16384 \quad 4096 \quad 1024 \quad 256 \quad 64 \quad 16 \quad 4 \quad 1 \text{ } \& c. \text{ decreasing by } 4 \end{array} \right.$

are ranks of numbers in Geometric Progression; and of such ranks there may be an infinite variety.

61. The common Multiplier or Divisor is called the *ratio*.

Thus 2 is the ratio in the 1st. rank, 5 in the 2d. rank, 3 is the ratio in the 3d. rank, and 4 in the 4th. rank.

62. In any series of terms in Arithmetic Progression, the sum of any two terms, considered as extremes, is equal to the sum of any two terms taken as means equally distant from the extremes.

Thus in 3 terms (where the 1st. and 3d. are extremes, and the other the mean) viz. 6 . 9 . 12; then $6+12=9+9=18$.

And in 4 terms, viz. 13 . 19 . 25 . 31.

Then $13+31=19+25=44$.

Also in the terms 49 . 43 . 37 . 31 . 25 . 19 . 13 . 7 . 1.

Then $49+1=43+7=37+13=31+19=25+25=50$.

63. In a series of terms in Geometric Progression, the Product of any two terms considered as extremes, is equal to the Product of any two intermediate equidistant terms considered as means.

Thus in 3 terms, viz. 5 . 25 . 125. Or 3 . 9 . 27.

Then $5 \times 125 = 25 \times 25 = 625$. Also $3 \times 27 = 9 \times 9 = 81$.

And in 4 terms 4 . 8 . 16 . 32.

Then $32 \times 4 = 16 \times 8 = 128$.

Also in the terms 1 . 4 . 16 . 64 . 256 . 1024 . 4096 . 16384.

Then $16384 \times 1 = 4096 \times 4 = 1024 \times 16 = 256 \times 64 = 16384$.

64. PROBLEM I. *In an Arithmetic Progression: Given the first term, the common difference, and the number of terms.*

Required the last term.

RULE. Multiply the number of terms less one by the common difference, to the Product add the first term, and the sum will be the last term.

Ex. I. Suppose 1 and 9 to be the first and second terms of an Arithmetic Progression of 1074 terms: What is the last term?

Here $9 - 1 = 8$ is the com. diff. Now $1074 - 1 = 1073$.
And $1073 \times 8 = 8584$. Then $8584 + 1 = 8585 =$ last term.

Ex. II. A person agrees to discharge a certain debt in a year, by weekly payments, viz. the first week 5 s. the 2d. week 8 s. &c. constantly increasing each week by 3 s: How much was the last payment?

$5 = 1^{\text{st.}}$ term Now $52 - 1 = 51$
 $3 =$ com. diff. And $51 \times 3 = 153$
 $52 = N^{\circ}.$ of terms. Then $153 + 5 = 158 \text{ s.} = 7 \text{ £. } 18 \text{ s.} =$ last payment.

65. PROBLEM II. *In an Arithmetic Progression: Given the first term, last term, and the number of terms.*

Required the sum of all the terms.

RULE. Add the first and last terms together, the sum multiplied by half the number of terms, gives the sum of all the terms.

Ex. I. Required the sum of the first 1000 numbers in their natural order.

Here $1 = 1^{\text{st.}}$ term, $1 =$ com. diff.
 $1000 = N^{\circ}.$ of terms, its $\frac{1}{2}$ is 500.
Now $1000 + 1 = 1001$.
Then $1001 \times 500 = 500500$ is the sum required.

Ex. II. A debt is to be discharged in a year by weekly payments equally increasing; the 1^{st.} to be 5 s. and the last 7 £. 18 s: How much was the debt?

Here $7 \text{ £. } 18 \text{ s.} = 158 \text{ s.} =$ last term.
 $52 = N^{\circ}.$ of terms, its $\frac{1}{2}$ is 26.
Now $158 + 5 = 163$.
Then $163 \times 26 = 4238 \text{ s.} = 211 \text{ £. } 18 \text{ s.}$
is the sum of the terms, or debt.

Ex. III. Suppose a basket and 500 stones were placed in a strait line a yard distant from one another: Required in what time a man could bring them one by one to the basket, allowing him to walk at the rate of 3 miles an hour?

Between the basket and stones are 500 spaces, which is the $N^{\circ}.$ of terms.
Now $500 + 1 = 501$. Then $501 \times 250 = 125250 =$ sum of the terms.
But as he goes backwards and forwards, he walks 250500 yards.
Which divided by 1760 (the yards in 1 mile) gives 142,329 miles.
Which at 3 miles an hour, will take 47 h. 26 min. 34 seconds.

66. PROBLEM III. *In a Geometric Progression: Given the first term, the ratio and the last term.*

Required the sum of all the terms.

RULE. Multiply the last term by the common ratio, from the Product subtract the first term for a Dividend.

Subtract 1 from the ratio for a Divisor; then divide, and the Quotient will be the sum of all the terms.

Ex. I. *Suppose the first term of a series to be 3, the ratio 3, and the last term 6561: Required the sum of all the terms.*

$$\begin{array}{rcl}
 \text{Now} & 6561 = \text{last term} & \text{And } 3 = \text{ratio} \\
 \text{Mult. by} & 3 = \text{ratio} & \text{Subt. } 1 \\
 \hline
 & 19683 = \text{Product} & \text{Rem. } 2 = \text{Divisor.} \\
 \text{Subtr.} & 3 = \text{first term} & \\
 \hline
 & 19680 = \text{Dividend} &
 \end{array}$$

Then $2) 19680$ (9840 is the sum of all the terms.

Ex. II. *Let the first term be 2, the second term 10, and the last term 156250: Required the sum of all the terms.*

Here $2) 10$ (5 is the common ratio.

Now $156250 \times 5 = 781250$. And $781250 - 2 = 781248 = \text{Dividend}$.

Also $5 - 1 = 4$ the Divisor.

Then $4) 781248$ (195312 is the sum of all the terms.

67. PROBLEM IV. *In a Geometric Progression: Given the first term, the ratio, and the number of terms.*

Required the last term.

RULE. Raise the common ratio to a power less 1 than the number of terms; multiply this power by the first term, and the Product will be the last term.

Ex. I. *What is the 10th term of a Geometric Series whose first term is 2, and the second term is 6?*

Here $2) 6$ (3 is the common ratio.

Then $3 \times 3 = 9 = 2d. \text{ power.}$

$9 \times 3 = 27 = 3d.$

$27 \times 3 = 81 = 4th.$

$81 \times 3 = 243 = 5th.$

$243 \times 3 = 729 = 6th.$

$729 \times 3 = 2187 = 7th.$

$2187 \times 3 = 6561 = 8th.$

$6561 \times 3 = 19683 = 9th.$

$19683 \times 2 = 39366 = 10th. \text{ term.}$

Ex. II. *What is the 12th term of a Geometric Series whose first term is 3, and 2d. term is 6?*

Here $3) 6$ (2 is the com. ratio.

Then 2 raised to the 11th power as in Ex. I. will be 2048, which multiplied by 3 the 1st. term gives 6144 for the 12th. term sought.

As this method is extremely tedious when a distant term from the first is required; therefore the following method is most convenient for such operations.

68. In any Arithmetic Progression, the sum of any two terms lessened by the first term, or their difference increased by the first term, will be also a term in that progression.

Thus in the Progression 1. 3. 5. 7. 9. 11. 13. 15. 17. 19. 21 &c.

Then $7+11=18$, and $18-1=17$ is a term of the Progression.

Also $11-7=4$, and $4+1=5$ is a term of the Progression.

And the like of the sum or difference of any other two terms.

69. In any Geometric Progression, the product of any two terms divided by the first term; or the Quotient of any two terms multiplied by the first term, will give a term also in that series.

Thus in the progression 3. 6. 12. 24. 48. 96. 192, 384, 768, &c.

Then $\frac{12 \times 96}{3} = 384$; and $\frac{192}{12} \times 3 = 48$, are terms in the Progression.

70. If over a series of terms in Geometric Progression, be wrote a series of terms in Arithmetic Progression, whose first term is 0, and com. diff. is 1, term for term; then any term in the Arithmetic Series, will shew how far its corresponding term in the Geometric Series, is distant from the first term.

Thus $\left\{ \begin{array}{l} 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ \&c. \text{ Arithmetic Series.} \\ 1 \ 3 \ 9 \ 27 \ 81 \ 243 \ 729 \ \&c. \text{ Geometric Series.} \end{array} \right.$

Here 729 is distant from the 1st. term, 6 terms; 243 is distant 5 terms; 81 is distant 4 terms &c.

71. The terms of the Arithmetical Series are called Indices to the terms of the Geometrical Series.

And hence arises the following ready method of finding any distant term in a proposed Geometric Progression.

72. RULE, 1st. Write down 6 or 7 of the leading terms in the Geometric Series, and over them their Indices.

2d. Add together the most convenient Indices to make an Index less by one than the number expressing the place of the term sought.

3d. Multiply together the terms of the Geometric Series, belonging to those Indices which were added, make the product a Dividend.

4th. Raise the first term to a power whose Index is the number of terms multiplied less one; make the result a Divisor to the former Dividend, and the Quotient will be the term sought.

When the first term is Unity, the foresaid Dividend is the term sought.

Ex. What is the 20th term in the Geometric Series 1 . 3 . 9 . 27 . &c. ?

Here $\left\{ \begin{array}{l} 0 \ 1 \ 2 \ 3 \ 4 \ 5 \ 6 \ \&c. \text{ Indices.} \\ 1 \ 3 \ 9 \ 27 \ 81 \ 243 \ 729 \ \&c. \text{ Geom. terms.} \end{array} \right.$

And

And as 20 is the number of the place of the term sought ; therefore such Indices are to be added together, as will most readily make 19.

Then $6+6=12$; $12+6=18$; and $18+1=19$ is the Index to the 20th term. Now the Geom. term belonging to the Index 6, is 729.

And as the sum of 6 and 6 made the Index 12.

So $729 \times 729 = 531441$ is the Geom. term to the Index 12.

And as the sum of 6 and 12 made the Index 18.

So $531441 \times 729 = 387420489$ is the Geom. term to the Index 18.

And as the sum of 18 and 1 made the Index 19.

So 387420489×3 (belonging to the Index 1) $= 1162261467$ is the Geom. term to the Index 19, or the 20th term in the proposed series.

SECTION IX. OF LOGARITHMS.

73. LOGARITHMS are a series of numbers so contrived, that by them the work of multiplication may be performed by addition ; and that of division may be done by subtraction.

These Logarithms are the Indices to a series of numbers in Geometrical Progression.

Thus	{	0	1	2	3	4	5	6	Indices or Logarithms.
		1	2	4	8	16	32	64	Geometric Progression.
		0	1	2	3	4	5	6	Indices or Logarithms.
		1	2	4	8	16	32	64	Geometric Series.
or	{	0	1	2	3	4	5	6	Indices or Logarithms.
		1	10	100	1000	10000	100000	1000000	Geom. Series.

These Indices serve equally for any Geometric Series.

74. Hence it is evident there may be as many kinds of Indices or Logarithms, as there can be taken kinds of Geometric Series.

75. But the Logarithms most convenient for common uses, are those adapted to a Geometric Series increasing in a tenfold Progression, as in the last of the examples above.

Now in this Geometric Series, between the terms 1 and 10, if the numbers 2 . 3 . 4 . 5 . 6 . 7 . 8 . 9 were interposed, to them might Indices be also adapted in an Arithmetic Progression, suited to the terms interposed between 1 and 10, considered as a Geometric Progression : Also proper Indices may be found to all the numbers that can be interposed between any two terms of the Geometric Series.

But it is evident that all the Indices to the numbers under 10 must be less than 1 ; that is, are fractions : Those to the numbers between 10 and 100 must fall between 1 and 2 ; that is, are mixed numbers consisting of 1 and some fraction : And so the Indices to the numbers between 100 and 1000 will fall between 2 and 3 ; that is, are mixed numbers consisting of 2 and some fraction : And so of the other Indices.

76. Hereafter the integral part only of these Indices, will be called the Index ; and the fractional part will be called the Logarithm : And the computing of these fractional parts is called the making of Logarithms ; the most troublesome part of this work is to make the Logarithms of the prime numbers ; that is, of such numbers which cannot be divided by any other number than by itself and unity.

77.

To find the Logarithms of prime numbers.

RULE, 1st. Let the sum of the proposed number and its next lesser number be called A.

2d. Divide 0,868588963 by A, reserve the Quotient.

3d. Divide the reserved Quotient by the Square of A, reserve this Quotient.

4th. Divide the last reserved Quotient by the Square of A, reserving the Quotient; and thus proceed as long as division can be made.

5th. Write the reserved Quotients orderly under one another, the first being uppermost.

6th. Divide these Quotients respectively by the odd numbers 1 . 3 . 5 . 7 . 9 . 11, &c. that is, divide the first reserved Quotient by 1, the 2d. by 3, the 3d. by 5, the 4th. by 7, &c. let these Quotients be wrote orderly under one another, add them together, and their sum will be a Logarithm.

7th. To this Logarithm, add the Logarithm of the next lesser number, and the sum will be the Logarithm of the number proposed.

Ex. I. Required the Logarithm of the number 2.

Here the next less number is 1. And $2+1=3=A$.

And the Square of A is 9. Then

$\begin{array}{r} 0,868588963 \\ 3 \overline{) } \\ \hline 0,289529654 \\ 9 \overline{) } \\ \hline 0,032169962 \\ 9 \overline{) } \\ \hline 0,003574440 \\ 9 \overline{) } \\ \hline 0,000397160 \\ 9 \overline{) } \\ \hline 0,000044129 \\ 9 \overline{) } \\ \hline 0,000004903 \\ 9 \overline{) } \\ \hline 0,000000545 \\ 9 \overline{) } \\ \hline 0,000000060 \end{array}$	And	$\begin{array}{r} ,289529654 \\ 1 \overline{) } \\ \hline ,032169962 \\ 3 \overline{) } \\ \hline ,003574440 \\ 5 \overline{) } \\ \hline ,000397160 \\ 7 \overline{) } \\ \hline ,000044129 \\ 9 \overline{) } \\ \hline ,000004903 \\ 11 \overline{) } \\ \hline ,000000545 \\ 13 \overline{) } \\ \hline ,000000060 \\ 15 \overline{) } \\ \hline \end{array}$
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To this Log.

Add the Log. of

0,301029994

1=0,000000000

Their sum is the Log. of 2=0,301029994

This process needs no other explanation than comparing it with the rule.

78. The number 0,868588963 is the Quotient of 2 divided by 2,302585093, which is the Logarithm of 10, according to the first form of the Lord *Nepier*, who was the inventor of Logarithms. The manner whereby *Nepier's* Log. of 10 is found, may be seen in many books of Algebra;

Algebra; but is here omitted, because this treatise does not contain the elements of that science: However those who have not opportunity to enter thoroughly into this subject, had better grant the truth of one number, and thereby be enabled to try the accuracy of any Logarithm in the tables, than to receive those tables as truly computed, without any means of examining the certainty thereof.

That the manner of computing these Logarithms may be familiar to the reader, the operations of making several of them are here subjoined.

Ex. II. *Required the Logarithm of the number 3.*

Here the next less number is 2; and $3+2=5=A$, whose Square is 25.

$\begin{array}{r} 0,868588963 \\ \hline 5 \\ 0,173717792 \\ \hline 25 \\ 0,006948712 \\ \hline 25 \\ 0,000277948 \\ \hline 25 \\ 0,000011118 \\ \hline 25 \\ 0,000000445 \\ \hline 25 \end{array}$	$\begin{array}{r} 173717792 \\ \hline 1 \\ 6948712 \\ \hline 3 \\ 277948 \\ \hline 5 \\ 11118 \\ \hline 7 \\ 445 \\ \hline 9 \\ 18 \\ \hline 11 \end{array}$
--	--

To this Logarithm
Add the Log. of 2.

The sum is the Logarithm of 3

$$\begin{array}{r} 0,176091256 \\ 0,301029992 \\ \hline 0,477121250 \end{array}$$

Since the Logarithms are the Indices of numbers considered in a Geometric Progression; therefore the sums, or differences, of these Indices, will be Indices or Logarithms belonging to the Products, or Quotients, of such terms in the Geometric Progression as correspond to those Logarithms as were added or subtracted. (72).

Ex. III. *Required the Log. of 4.*

Now $4=2 \times 2$.

$$\begin{array}{r} \text{Then to the Log. of 2} \quad 0,301029992 \\ \text{Add the Log. of 2} \quad 0,301029992 \\ \hline \text{Sum is the Log. of 4} \quad 0,602059984 \end{array}$$

Ex. V. *Required the Log. of 10.*
In the original Series, 1 is assumed for the Logarithm of 10.

Ex. IV. *Required the Log. of 6.*

Now $3 \times 2=6$.

$$\begin{array}{r} \text{Then to the Log. of 3} \quad 0,477121250 \\ \text{Add the Log. of 2} \quad 0,301029992 \\ \hline \text{Sum is the Log. of 6} \quad 0,778151242 \end{array}$$

Ex. VI. *Required the Log. of 5.*

Now 10 divided by 2 gives 5.

$$\begin{array}{r} \text{Then from Log. of 10} \quad 1,000000000 \\ \text{Take Log. of 2} \quad 0,301029992 \\ \hline \text{Leaves the Log. of 5} \quad 0,698970008 \end{array}$$

Ex. VII. *Required the Log. of 8.*

Now $8=2 \times 2 \times 2$.

Therefore the Log. of 2 taken thrice gives the Log. of the number 8.

$$\begin{array}{r} \text{The Log. of 2 is} \quad 0,301029992 \\ \text{Which multiplied by} \quad 3 \\ \hline \text{Gives the Log. of 8.} \quad 0,903089976 \end{array}$$

Ex. VIII. *Required the Log. of 9.*

Now $9=3 \times 3$.

Therefore the Log. of 3 doubled gives the Log. of 9.

$$\begin{array}{r} \text{The Log. of 3 is} \quad 0,477121250 \\ \text{Which multiplied by} \quad 2 \\ \hline \text{Gives the Log. of 9.} \quad 0,954242500 \end{array}$$

Ex.

Ex. IX. Required the Logarithm of 7.

Here 6 is the next lesser. Then $7+6=13=A$; and $169=\text{Square of } A$,

$$\frac{0,868588963}{13} = ,066814536. \quad \text{And} \quad \frac{,066814536}{1} = ,066814536$$

$$\frac{0,066814536}{169} = 395352. \quad \& \quad \frac{395352}{3} = 131784$$

$$\frac{0,000395352}{169} = 2339. \quad \& \quad \frac{2339}{5} = 468$$

$$\frac{0,000002339}{169} = 14. \quad \& \quad \frac{14}{7} = 2$$

To this Logarithm	0,066946790
Add the Logarithm of 6	0,778151242

The sum is the Logarithm of 7	0,845098032
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The Log. of 12 is equal to the sum of the Logs. of 3 & 4, or of 2 & 6.

The Log. of 14 is equal to the sum of the Logs. of 7 & 2

of 15	of 3 & 5
of 16	of 4 & 4, or of 8 & 2
of 18	of 3 & 6, or of 9 & 2
of 20	of 4 & 5, or of 10 & 2

79. The Logs. of the prime numbers 11, 13, 17, 19, are to be found as in the examples I. II. IX. and in like manner is the Log. of any other prime number to be found; but it may be observed, that the operation is shorter in the larger prime numbers; for any number exceeding 400, the first Quotient added to the Logarithm of its next lesser number, will give the Logarithm sought, true to 8 or 9 places; and therefore it will be very easy to examine any suspected Logarithm in the tables.

80. The manner of disposing the Logarithms when made, into tables is various: But in this treatise they are ordered as follows.

Any number under 100, or not exceeding two places, and its Logarithm, is found in the first page of the table, where they are placed in adjoining columns; and distinguished by the title *Num.* for the common numbers; and by *Log.* for the Logarithms.

A number of three or four places being given, its Logarithm is thus found.

Seek for a page in which the given number shall be contained between the two numbers marked at the top, annexed to the letter N: Then right against the three first figures of the given number, found in the column signed *Num.* and in the column signed by the fourth, stands the Logarithm belonging to that number of four places.

If the number consisted of 3 places only; then these places found as before directed, the Logarithm stands against them in the column signed 0.

Thus,

Thus, to find the Logarithm of 5738. Seek for a page wherein stands at top N. 5500 to 6000; then in the column signed Num. find 573, right against which in the column signed 8, stands ,75876 which is the Logarithm to 5738, exclusive of its Index.

81. A Logarithm being given, its number is thus found.

Seek for a page wherein the three first figures of the given Logarithm is found at top annexed to the letter L; then in one of the columns signed with the figures 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, find a number the nearest to the given Logarithm; against this number in the column signed Num. stand three figures, to the right of these annex the figure with which the column was signed, and this will be the number corresponding to the given Logarithm, not regarding the Index.

82. A general rule to find the Index to the Log. of a given number.

To the left of the Logarithm, write that figure (or figures) which expresses the distance from unity, of the highest-place digit in the given number, reckoning the unit's place 0, the next place 1, the next place 2, the next place 3, &c.

When there are integers in the given number, the Index is always affirmative; but when there are no integers, the Index is negative, and is to be marked by a little line drawn above it: thus $\overline{2}$.

Thus a number having 1 . 2 . 3 . 4 . 5 &c. integer places.

The Index of its Logarithm is 0 . 1 . 2 . 3 . 4 &c.

And a fraction having a digit in the place of Primes. Seconds. Thirds. Fourths &c.

Then the Index of its Logarithm will be $\overline{1}$. $\overline{2}$. $\overline{3}$. $\overline{4}$ &c.

By the above rule, the place of the fractional comma, or mark of distinction, in the number answering to a given Logarithm, will be always known.

83. The more places the Logarithms consist of, the more accurate, in general, will be the result of any operation performed with them: But for the purposes of Navigation, as five places, exclusive of the Index, are sufficient, therefore the logarithmic tables in this treatise are not extended any farther.

84. All numbers consisting of the same figures, whether they be integral, fractional, or mixed, have the fractional parts of their Logarithms the same.

If the following examples be well attended to, there will be no difficulty in finding the Logarithm to a proposed number, or the number to a proposed Logarithm, within the limits of the table of Logarithms here used.

Num.	Logarithms	Logarithms	Numbers.
5874	3,76893	0,37295	2,360
587,4	2,76893	1,28631	19,33
58,74	1,76893	2,51947	330,7
5,874	0,76893	3,75062	5632,
0,5874	$\overline{1}$,76893	$\overline{3}$,18397	0,001527
0,05874	$\overline{2}$,76893	$\overline{2}$,43020	0,02693
0,005874	$\overline{3}$,76893	$\overline{1}$,85962	0,7238

85. MUL-

85. MULTIPLICATION BY LOGARITHMS;

Or, Two or more numbers being given, to find their Product by Logarithms.

RULE. Add together the Logarithms of the Factors, and the sum is a Logarithm, whose corresponding number is the Product required.

Observing to add what is carried from the Logarithm to the sum of the affirmative Indices.

And that the difference between the affirmative and negative Indices are to be taken for the Index to the Logarithm of the Product.

Ex. I. Multiply 86,25 by 6,48.

86,25 its Log. is 1,93576
6,48 its Log. is 0,81157

Product 558,9 2,74733

Ex. III. Multiply 3,768 by 2,053 and by 0,007693.

3,768 its Log. is 0,57611
2,053 0,31239
0,007693 3,88610

Product 0,05951 2,77460

The 1 carried from the left hand column of the Logs. being affirmative, reduces $\frac{3}{3}$ to $\frac{2}{2}$.

Ex. II. Multiply 46,75 by 0,3275.

46,75 its Log. is 1,66978
0,3275 its Log. is 1,51521

Product 15,31 1,18499

Ex. IV. Multiply 27,63 by 1,859 and by 0,7258 and by 0,03591.

27,63 its Log. is 1,44138
1,859 0,26928
0,7258 1,86082
0,03591 2,55521

Product 1,339 0,12669

Here 2 being carried to the Index 1, makes 3; which takes off the $\frac{1}{1}$ and $\frac{2}{2}$.

86. DIVISION BY LOGARITHMS;

Or, Two numbers being given, to find how often the one will contain the other, by Logarithms.

RULE. From the Log. of the Dividend, subtract the Log. of the Divisor; then the number agreeing to the Remainder, will be the Quotient required.

But observe, to change the Index of the Divisor from negative to affirmative, or from affirmative to negative: And then let the difference of the affirm. and neg. Indices be taken for the Index to the Log. of the Quotient.

When an unit is borrowed in the left hand place of the Logarithm, add it to the Index of the Divisor, if affirmative; but subtract it if negative; and let the Index arising be changed and worked with as before.

Ex. I. Divide 558,9 by 6,48.

The Log. of the Div. 558,9 is 2,74733
The Log. of the Divisor 6,48 is 0,81157

The Quotient is 86,25 1,93576

Ex. II. Divide 15,31 by 46,75.

The Log. of the Div. 15,31 is 1,18497
The Log. of the Divisor 46,75 is 1,66978

The Quotient is 0,3275 1,51519

Ex. III. Divide 0,05951 its Log. is 2,77459
By 0,007693 3,88610

The Quotient is 7,735 0,88849

1st. State the terms of the question (by 46) and let them be wrote orderly under one another, prefixing to the first term the word *As*, to the second *To*, to the third *So*, and under them set the word *To*.

2d. Against the first term, write the arithmetical complement of its Logarithm.

3d. Against the second and third terms, write their Logarithms.

4th. The sum of these three Logarithms, abating 10 in the Index, will be the Logarithm of the fourth term; which sought in the tables, the number answering thereto, is the answer or term sought.

88. The arithmetical complement of a Logarithm is thus found. Beginning at the Index, write down what each figure wants of 9, except the last, which take from 10.

But if the Index is negative, add it to 9; and proceed with the rest as before.

Ex. I. Find a fourth proportional number to 98,45 and 1,969 and 347,2.

As	98,45	8,00678
To	1,969	0,29425
So	347,2	2,54058
To	6,944	0,84161

Ex. III. What will a gunner's pay amount to in a year at 2 £. 12 s. 6 d. a month of 28 days?

As	28 days	8,55286
To	365 days	2,56229
So	2 £. 12 s. 6 d. = 2,625 £.	0,41913
To	34 £. 4 s. 5 d. = 34,22 £.	1,53428

Ex. V. What number will have the same proportion to 0,8538 as 0,3275 has to 0,0131?

As	0,0131	11,88273
To	0,3275	1,51521
So	0,8538	1,93125
To	21,34	1,32919

Ex. II. Find a third proportional number to 9,642 and 4,821.

As	9,642	9,01583
To	4,821	0,68314
So	4,821	0,68314
To	2,411	0,38211

Ex. IV. If $\frac{3}{4}$ of a yard of cloth cost $\frac{2}{3}$ of a guinea: How many ells English for 3 £. 10 s?

As	$\frac{2}{3}$ Guin. = 14 s.	8,85387
To	3 £. 10 s. = 70 s.	1,84510
So	$\frac{3}{4}$ ell = 0,6	1,77815
To	3 ells	0,47712

Ex. VI. How many yards of shalloon of $\frac{3}{4}$ ell wide will be enough to line a coat containing $3\frac{1}{2}$ ells of $1\frac{3}{4}$ yards wide?

As	$\frac{3}{4} \times \frac{5}{4}$ yd. w. = 0,9375	10,02803
To	$1\frac{3}{4}$ yd. w. = 1,75	0,24304
So	$3\frac{1}{2} \times \frac{5}{4}$ yd. l. = 4,375	0,64098
To	$8\frac{1}{8}$ yd. long = 8,167	0,91205

OF POWERS AND THEIR ROOTS.

90. *A number being given, to find any proposed power thereof.*

RULE, 1st. Seek the Logarithm of the given number.

2d. Multiply this Logarithm by the Index of the proposed power.

3d. Find the number corresponding to the Product, and it will be the power required.

Ex. I. *What is the 2d. power of the number 3,874?*

To 3,874 its Log. is 0,58816
The Index is 2

The power sought is 15,01 1,17632

Ex. II. *What is the 3d. power of the number 2,768?*

The num. 2,768, its Log. is 0,44217
The Index is 3

The power sought is 21,21 1,32651

Ex. III. *What is the 12th. power of the number 1,539?*

1,539 its Log. is 0,18724
The Index is 12

The power sought is 176,6 2,24688

Ex. IV. *What is the 365th. power of the number 2?*

2 its Log. is 0,30103
The Index is 365

150515
180618

In the IV. Ex. the Index of the Product being 109, shews that the required power will consist of 110 integer places; of which no more than 4 places are found in these tables; therefore the number sought may be thus expressed 7515 [106]: That is 7515 with 106 cyphers annexed.

91. *A number being given, to find any proposed Root thereof.*

RULE. Divide the Logarithm of the given number or power, by the Index of the proposed Root; and the number corresponding to the Quotient will be the Root required.

Ex. I. *What is the Square Root of the number 1501?*

2) 3,17638
Root sought is 38,74 1,58819

Ex. II. *What is the Cube Root of the number 2121?*

3) 3,32654
Root sought is 12,85 1,10885

Ex. III. *What is the Root, whereof 176,6 is the 12th. power?*

12) 2,24686
Root sought is 1,539 0,18724

Ex. IV. *What is the Root, whereof 2 is the 365th. power?*

365) 0,30103
Root sought is 1,002 0,00082

G

T H E



THE
ELEMENTS
OF
NAVIGATION.

BOOK II.
OF GEOMETRY.

SECTION I.

Definitions and Principles.

92. **G**EOMETRY is a science which treats of the descriptions, properties and relations of magnitudes in general: Or of such things where length, or where length and breadth, or length breadth and thickness are considered.

93. A POINT is that which is without parts or dimensions.

A —————

C D

F

 G

94. A LINE is length without breadth: It is called a RIGHT LINE when 'tis the shortest distance between two points (as A B): Or a CURVED LINE when it is not the shortest distance (as C D).

A line is usually denoted by two letters, viz. one at each end (as A B, C D).

95. A SUPERFICIES or SURFACE is that magnitude which has only length and breadth, and is bounded by lines, as F G.

96. A SOLID is that magnitude which has length breadth and thickness.

(A) (B)
 C
 D E

97. A FIGURE is a bounded space, whose limits or bounds may be either lines or surfaces.

98. A PLANE or a PLANE FIGURE is a superficies which lies evenly, or perfectly flat, between its limits; and may be bounded by one curve line; but not with less than three right lines, as A, B, C, D or E, &c.

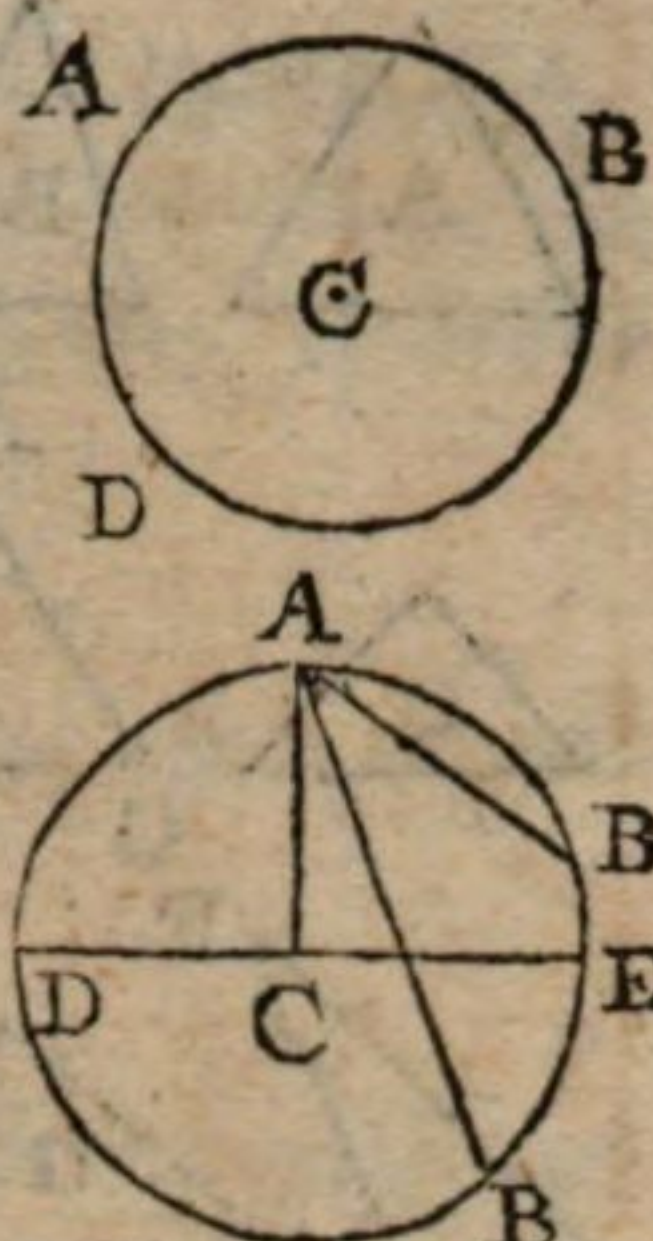
99. A

99. A **CIRCLE** is a plain figure bounded by an uniformly curved line called the **Circumference** (as $A B D$), which is every where equally distant from one point (C) within the figure, called the **CENTRE**.

100. A **RADIUS** is a right line drawn from the centre to the circumference (as $C A$, $C D$, $C E$).

All the radii of the same circle are equal.

101. An **ARC** is any part of the circumference (as $A B$ or $A D$).



102. A **CHORD** is a right line joining the ends of an arc (as $A B$) and is said to subtend that arc; it divides the circle into two parts called **segments**.

103. A **DIAMETER** is a chord passing thro' the centre (as $D E$), and divides the circle into two equal parts called **SEMICIRCLES**.

104. The **CIRCUMFERENCE** of every circle is supposed to be divided into 360 equal parts called **DEGREES**; each degree into 60 equal parts called **MINUTES**; each minute into 60 equal parts called **SECONDS**, &c.

105. A **PLANE ANGLE** is the aperture or inclination of two lines on the same plane, meeting in a point (as $A C B$).

A right lined angle is formed by two right lines. The point where the lines meet is called the *angular point* (as C).

The lines which form the angle are called *legs* (as $C A$, $C B$).

An angle is usually marked by three letters, viz. one at the angular point, and one at the other end of each leg; but that at the angular point is always to be read the middle letter (as $A C B$, or $B C A$).

106. The measure of a right lined angle, is an arc ($B A$) contained between the legs ($C B$, $C A$) including the angle, the angular point (C) being the centre of that arc.

107. A **RIGHT ANGLE** is that whose measure is a fourth part of the circumference of a circle, or ninety degrees. Thus the angle $A C B$ is a right angle.

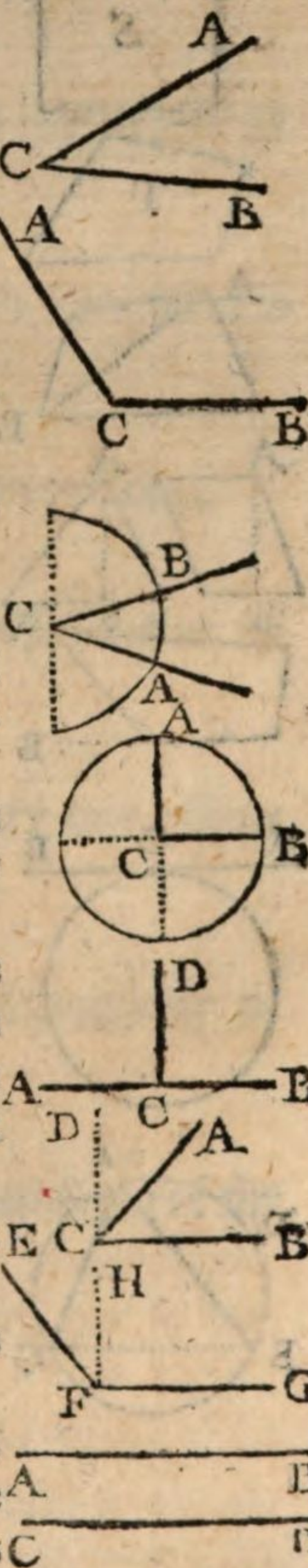
108. A **PERPENDICULAR** is that right line which cuts another at right angles; or which makes equal angles on both sides. Thus $D C$ is perpendicular to $A B$, when the angles $D C A$ and $D C B$ are equal, or are right angles.

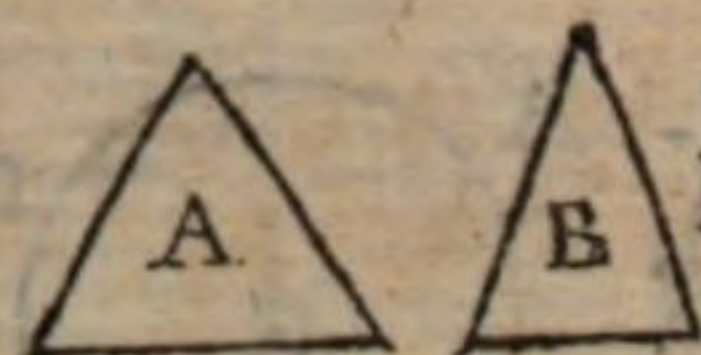
109. An **ACUTE ANGLE** ($A C B$) is that which is less than a right angle ($D C B$).

110. An **OBTUSE ANGLE** ($E E G$) is that which is greater than a right angle ($H F G$).

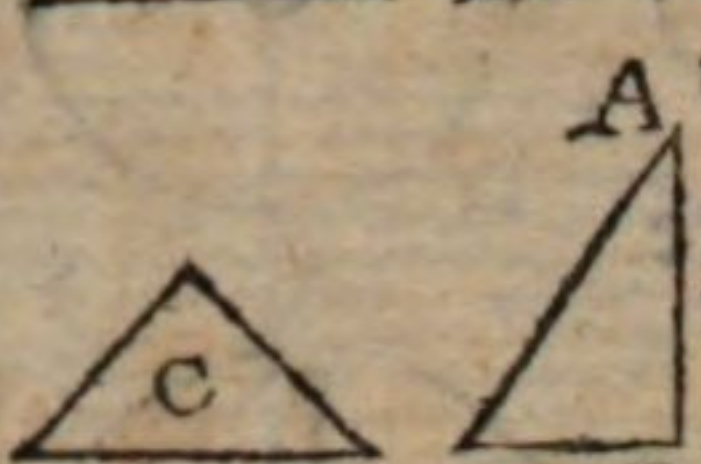
Acute and obtuse angles are called **OBLIQUE ANGLES**.

111. **PARALLEL LINES**, are such right lines in the same plane, which do not incline to one another (as $A B$, $C D$).



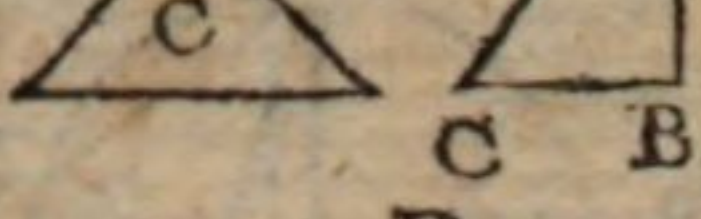


112. A TRIANGLE is a plane figure bounded by three lines.

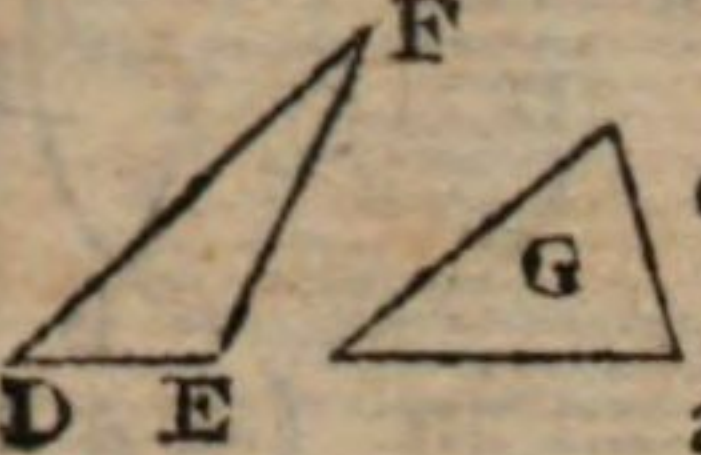


113. An EQUILATERAL TRIANGLE is that whose three lines or sides are equal (as A).

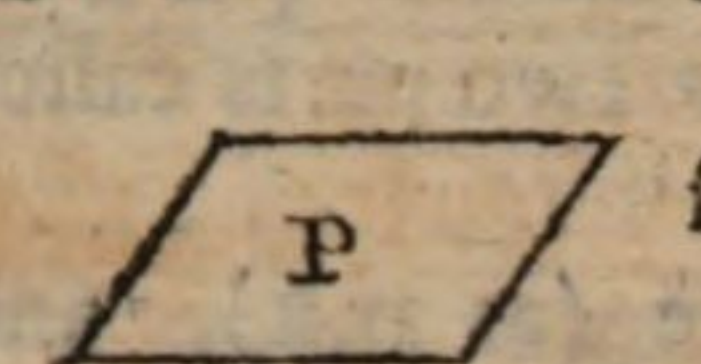
114. An ISOSCELES TRIANGLE is that which has only two equal sides (as B or C).



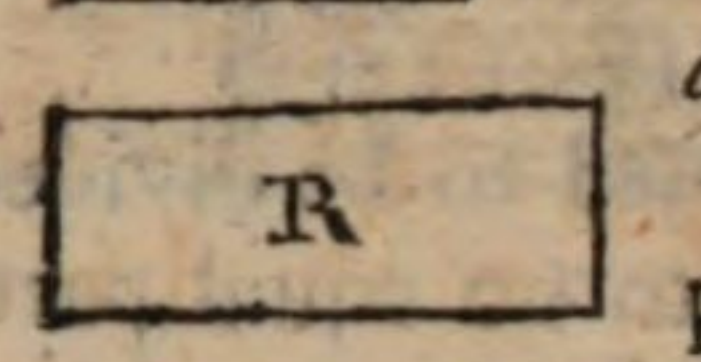
115. A RIGHT ANGLED TRIANGLE (A B C) is that which has one right angle (B).



116. An OBTUSE ANGLED TRIANGLE (D E F), has one obtuse angle (E).

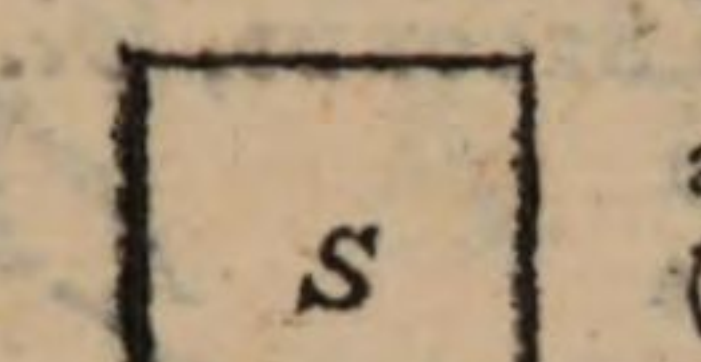


117. An ACUTE ANGLED TRIANGLE (G) has all its angles acute.



118. A QUADRANGLE is a plane figure bounded by four right lines or sides.

A Quadrangle is usually expressed by letters at the opposite angles.



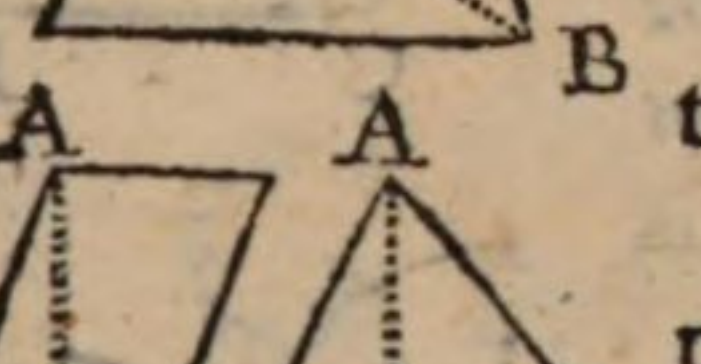
119. A PARALLELOGRAM is a quadrangle whose opposite sides are parallel and equal (as P).



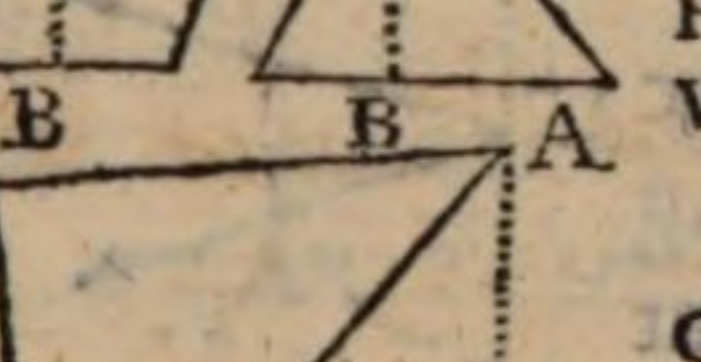
120. A RECTANGLE is a parallelogram with right angles; and whose length is greater than its breadth (as R).



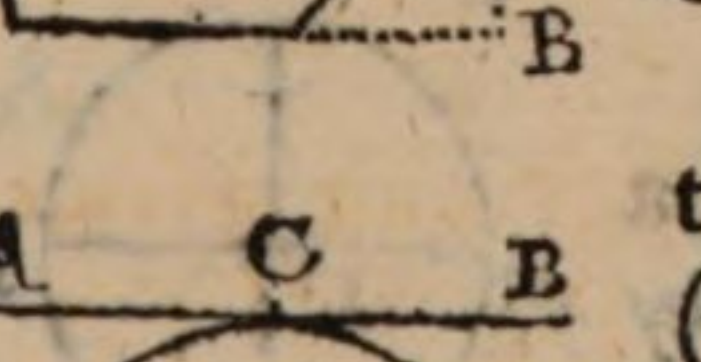
121. A SQUARE is a parallelogram having four equal sides, and right angles (as S).



122. A TRAPEZIUM is a quadrangle whose opposite sides are not parallel (as T).



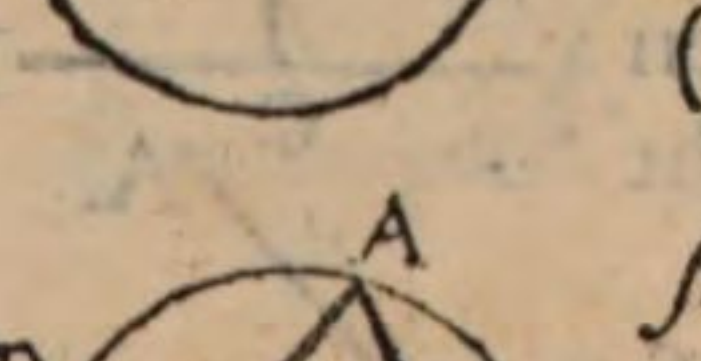
123. The DIAGONAL of a quadrangle, is a line (AB) drawn from one angle, to its opposite angle.



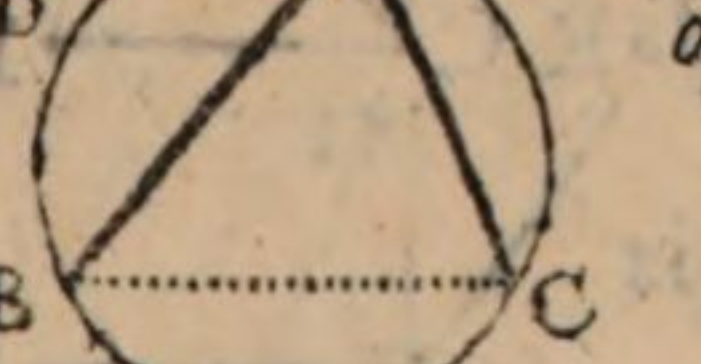
124. The BASE of a figure, is the line it is supposed to stand on.



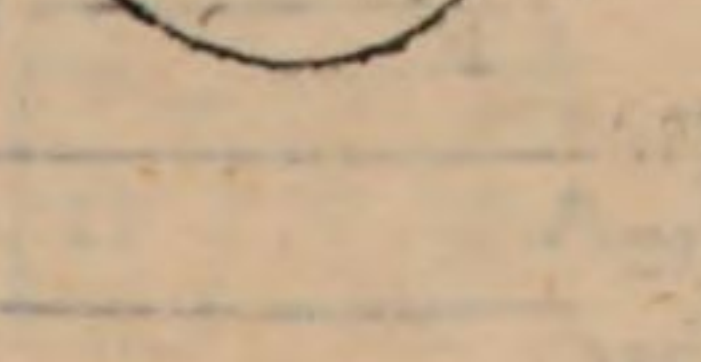
125. The ALTITUDE or HEIGHT of a figure, is the perpendicular distance (AB) between the base, and the vertex or part most remote from the base.



126. CONGRUOUS FIGURES, are those which agree, or correspond, with one another, in every respect.



127. A TANGENT to a circle is a right line (AB) touching its circumference but not cutting; and the point (C) where it touches, is called the point of contact.



128. An ANGLE (B A C) in a Segment (C A D B) is, when the angular point is in the circumference of the segment, and the legs including the angle pass thro' the ends (B, C) of the chord of the segment.

Such an angle is said to be in a circumference; and to stand on the arc (B C) included between the legs (A B, A C) of the angle.

129. Right lined figures having more than four sides, are called *Polygons*; and have their names from the number of their angles or sides; as those of five sides are called Pentagons; of six sides Hexagons; of seven sides Heptagons; of eight sides Octogons, &c.

130. A Regular Polygon is a figure with equal sides, and equal angles.

131. A figure is said to be inscribed in a circle, when all the angles of that figure are in the circumference of the circle.

132. A figure is said to circumscribe a circle, when every side is touched by the circumference of the circle.

133. A Proposition is something proposed to be considered; and requires either a solution or answer, or that something be made out or proved.

A Problem is a practical proposition, in which something is proposed to be done, or effected.

A Theorem is a speculative proposition, or rule, in which something is affirmed to be true.

A Corollary is some conclusion gained from a preceding proposition.

A Scholium is a remark on some proposition; or an exemplification of the matter which it contains.

An Axiom is a self evident truth, or principle, that every one assents to upon hearing it proposed.

A Postulate is a principle, or condition, requested; the simplicity or reasonableness of which cannot be denied.

In Mathematics, the following Postulates and Axioms, are some of the principles that are generally taken for granted.

POSTU-

P O S T U L A T E S.

134. I. That a right line may be drawn from any given point to another given point.

135. II. That a given right line may be continued, or lengthened, at pleasure.

136. III. That from a given point, and with any radius, a circle may be described.

A X I O M S.

137. I. Things equal to the same thing, are equal to one another.

138. II. If equal things are added to equal things, the sums or wholes will be equal. But if unequals be added, the sums are unequal.

139. III. If equal things are taken from equal things, the remainders or differences are equal: But are unequal, when unequals are taken.

140. IV. Things are equal, which are double, triple, quadruple &c. or half, third part &c. of one and the same thing, or of equal things.

141. V. Things which have equal measures, are equal.

142. VI. Equal circles have equal radii.

143. VII. Equal arcs in equal circles have equal chords, and are the measures of equal angles, and the contrary.

144. VIII. Parallel right lines, have each the same inclination to a right line cutting them.

In what follows. When a circle or arc is said to be described from a letter, it is to be understood as described from the point which that letter denotes, or marks out as a centre. And the like is to be understood of the points where lines or arcs cut one another.

145. It is also taken for granted, that a line or distance can be taken between the compasses and may be transferred or applied from one place to another.

SECTION II.

Geometrical Problems.

146.

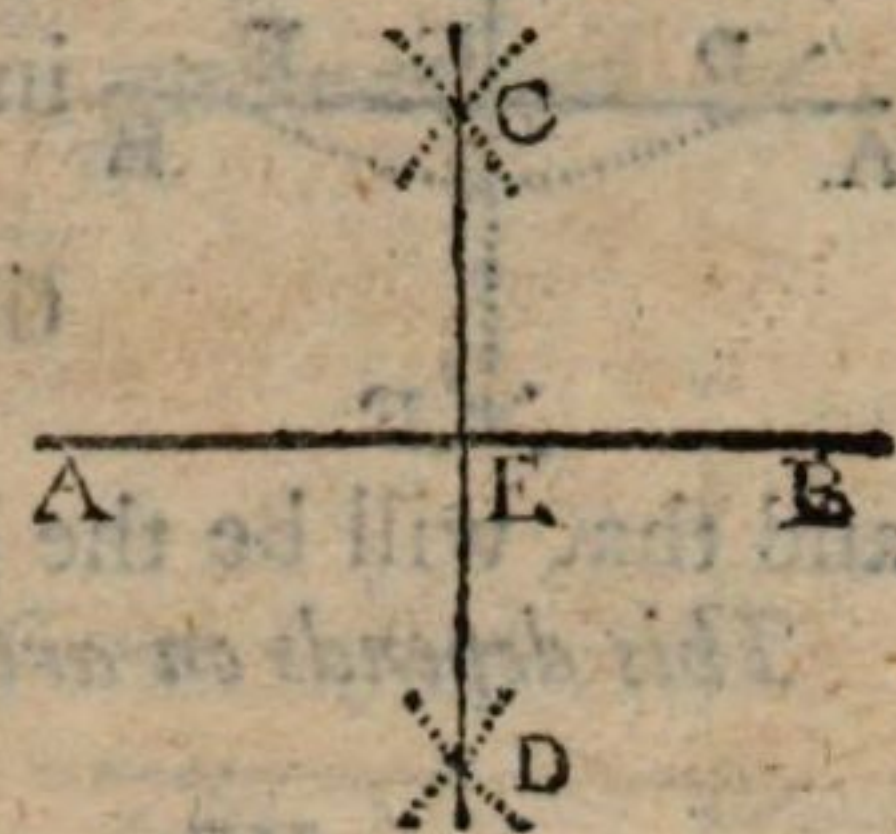
PROBLEM I.

To bisect, or divide into two equal parts, a given line A B.

OPERATION, 1st. From the ends A and B, with one and the same radius, greater than half A B, describe arcs cutting in C and D.

2d. A ruler laid by C and D, gives E, the middle of A B, as required.

The proof of this operation depends on articles 191, 189.



147.

PROBLEM II.

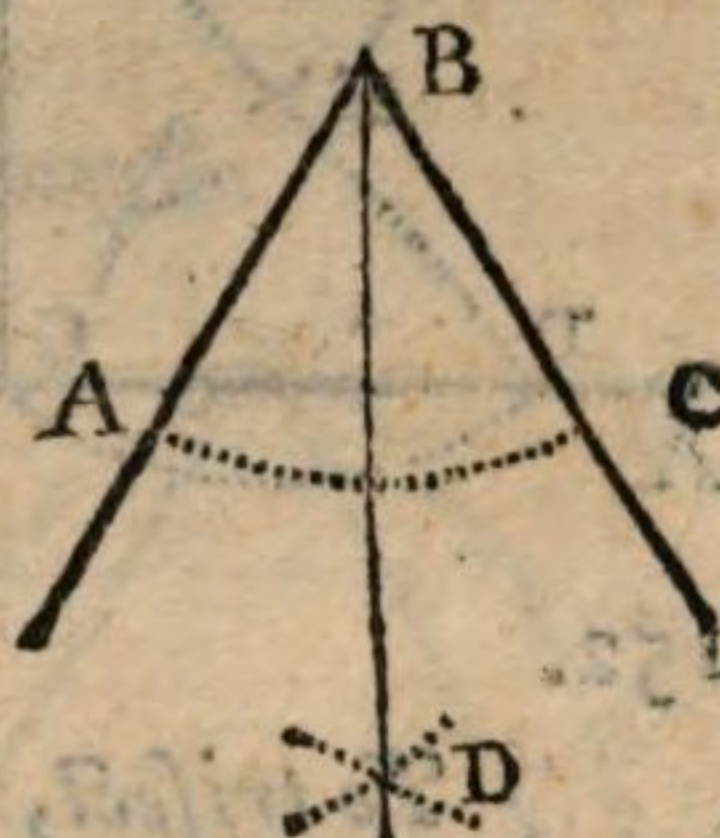
To bisect a given right lined angle A B C.

OPERATION, 1st. From B, describe an arc A C.

2d. From A and C, with one and the same radius describe arcs cutting in D.

3d. A right line drawn thro' B and D will divide the angle into two equal parts as required.

The proof depends on art. 191.



148.

PROBLEM III.

From a given point B, in a given right line A F, to draw a right line perpendicular to the given line.

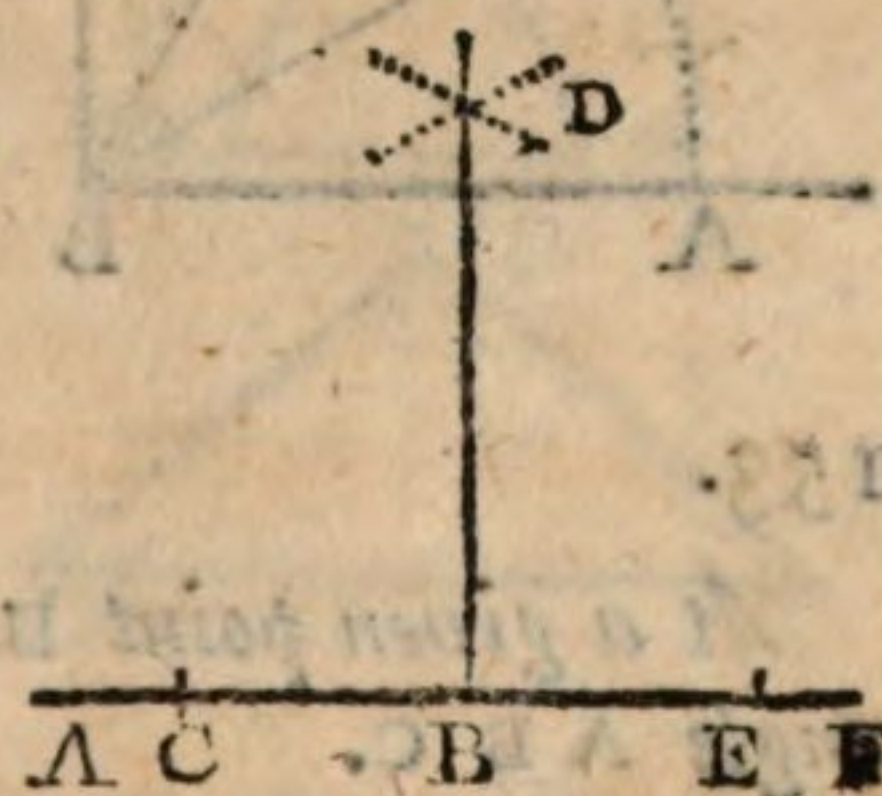
When B is near the middle of the line

OPERATION, 1st. On each side of B, take the equal distances B C, and B E.

2d. On C and E describe, with one radius, arcs cutting in D.

3d. A right line drawn thro' B and D will be the perpendicular required.

The proof depends on art. 193.



149.

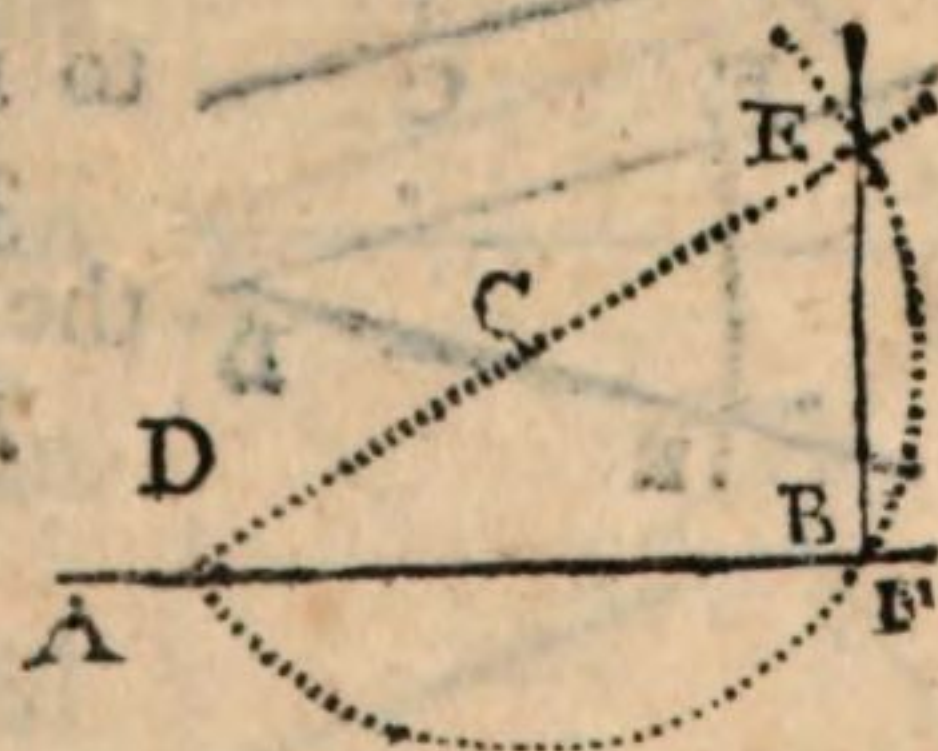
When B is at, or near the end of the given line.

OPERATION, 1st. On any convenient point C, taken at pleasure, with the distance or radius C B describe an arc D B E, cutting A F in D, B.

2d. A ruler laid by D and C will cut this arc in E.

3d. A right line drawn thro' B and E will be the perpendicular required.

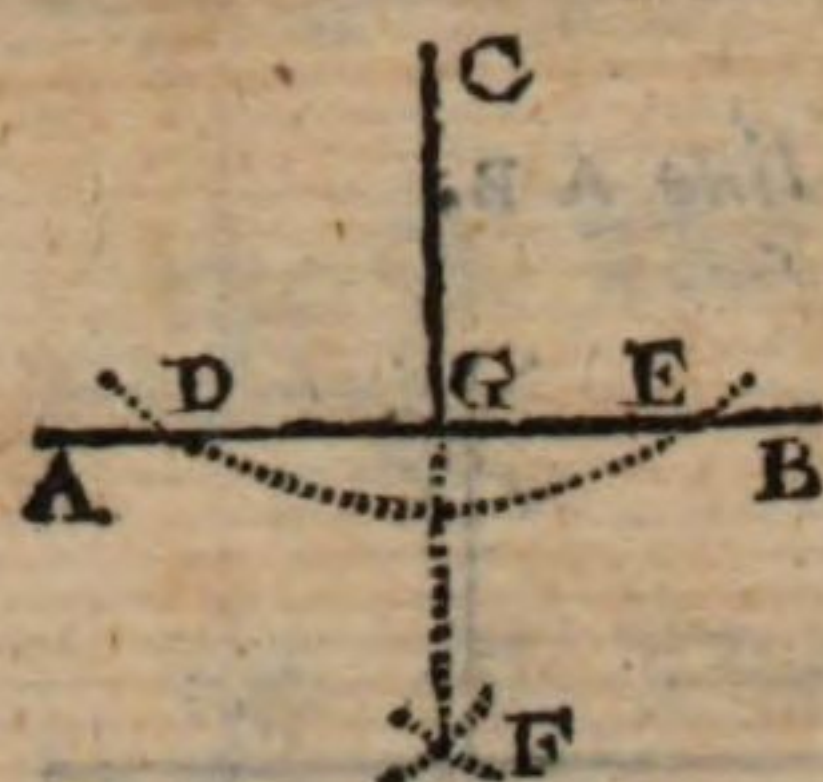
This depends on art. 213.



150.

PROBLEM IV.

To draw a line perpendicular to a given right line AB , from a point C without that line.



When the point C is nearly opposite to the middle of the given line.

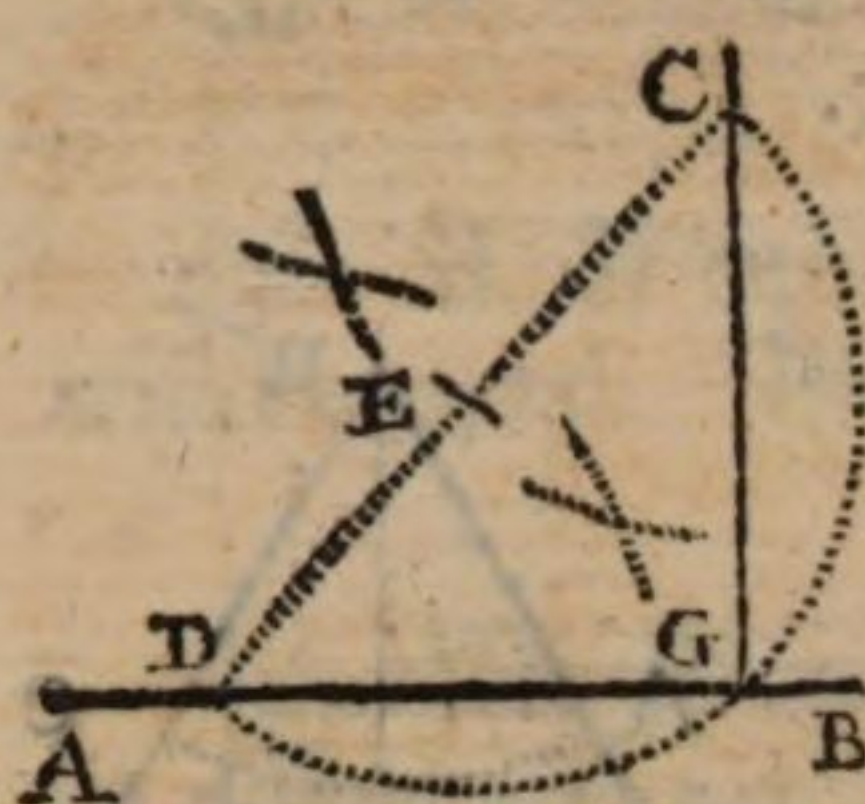
OPERATION, 1st. On C with one radius cut AB in D and E .

2d. On D and E with one radius describe arcs cutting in F .

A ruler laid by C and F gives G ; then draw CG and that will be the perpendicular required.

This depends on art. 191, 189.

151. When C is nearly opposite to one end of the given line AB .



OPERATION, 1st. To any point D in AB , draw the line CD .

2d. Bisect the line CD in E . (146).

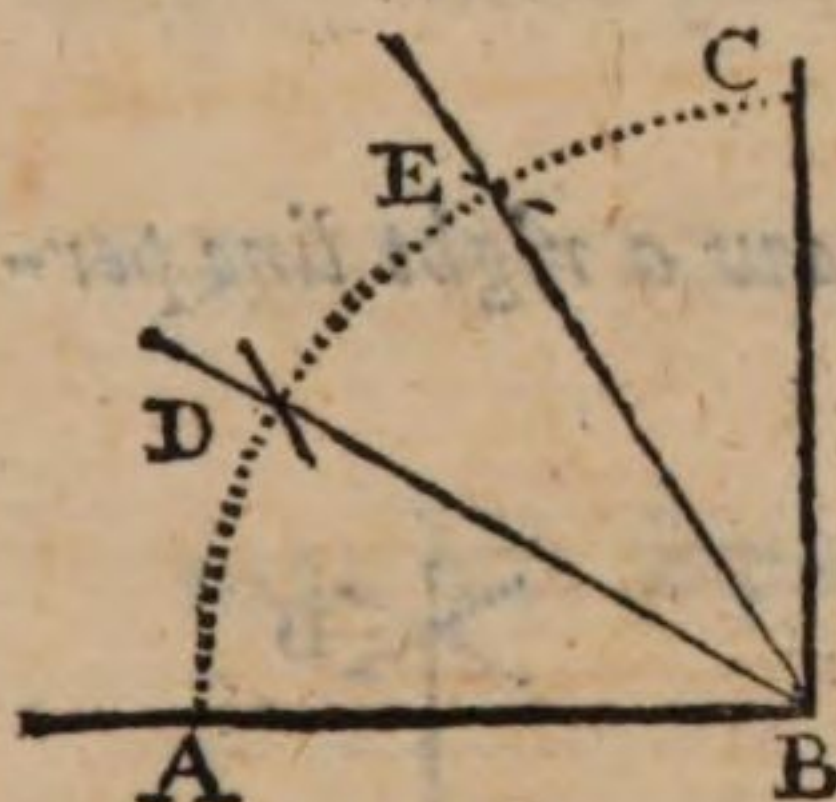
3d. On E with the radius EC , cut AB in G . Then CG being drawn will be the perpendicular required.

This depends on art. 213.

152.

PROBLEM V.

To trisect, or divide into three equal parts, a right angle ABC .



OPERATION, 1st. From B with any radius describe the arc AC .

2d. From A and C with the same radius, cut the arc AC in E and D .

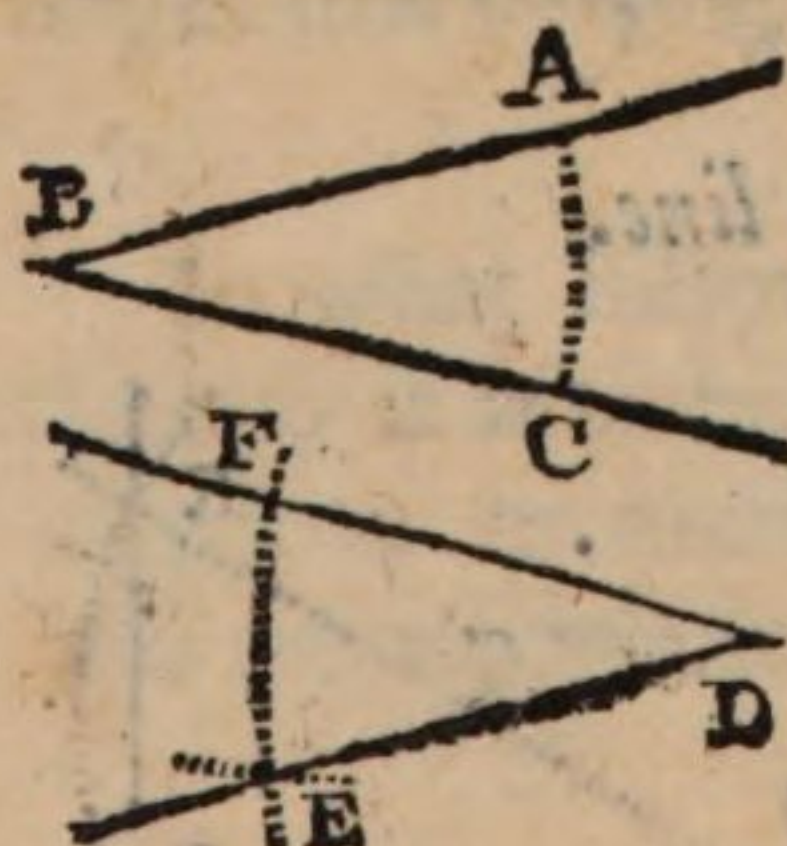
3d. Draw BE , BD , and the angle ABC will be divided into three equal parts.

This depends on art. 267.

153.

PROBLEM VI.

At a given point D , to make a right lined angle equal to a given right lined angle ABC .



OPERATION, 1st. From B and D with one radius describe the arcs AC , EF .

2d. Lay the distance AC on the arc EF from F to E .

3d. Lines drawn from D , thro' E and F , will form the angle EDF equal to the angle ABC .

This depends on art. 191.

154. PRQ

154.

PROBLEM VII.

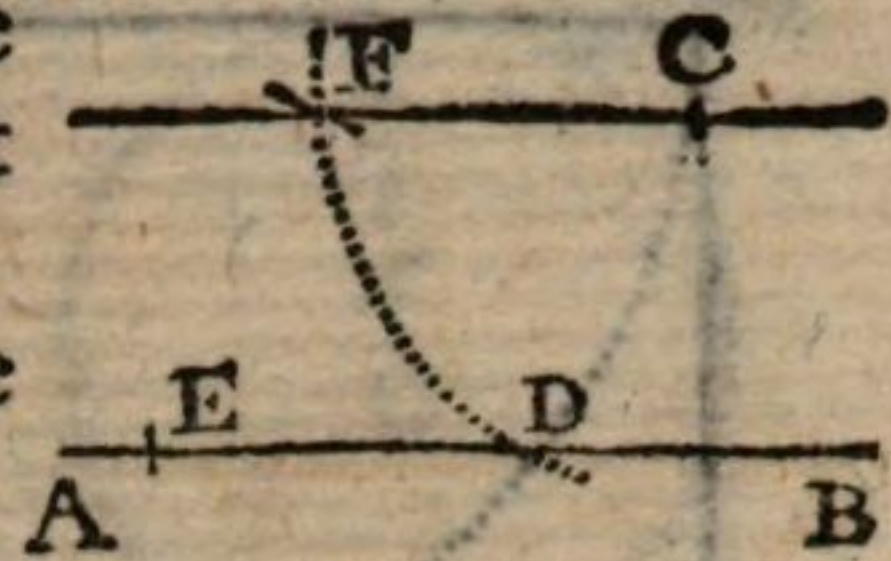
To draw a line parallel to a given right line AB.

When the parallel line is to pass thro' a given point C.

OPERATION, 1st. Take any point D in the line AB; and from that point with the radius DC, cut AB in E, and from E describe an arc F.

2d. From C, with the same radius CD, cut the arc in F.

3d. A line drawn thro' F and C will be parallel to AB.



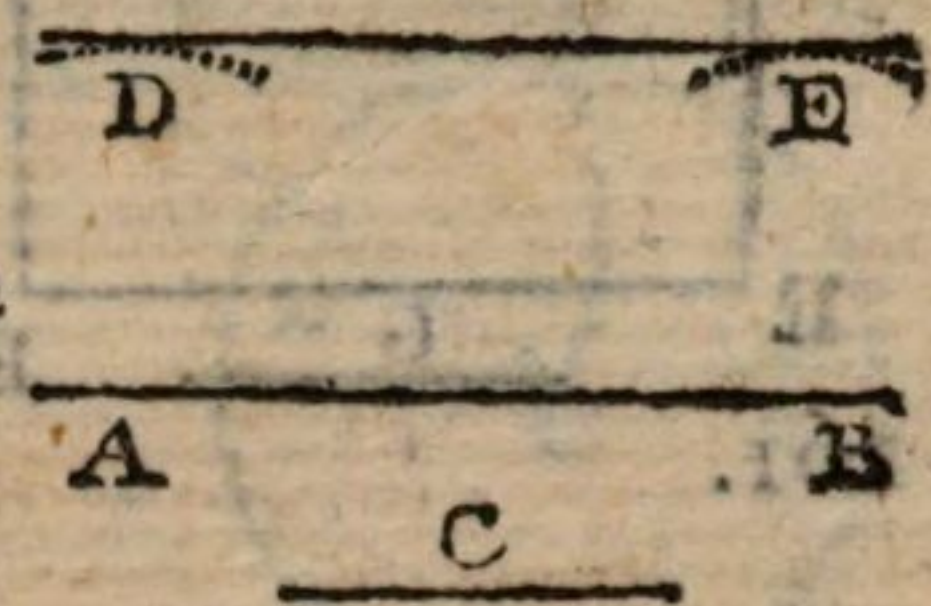
This depends on art. 191, 185.

155. *When the parallel line is to be at the given distance C from AB.*

OPERATION, 1st. From the points A and B, with the radius C, describe arcs D and E.

2d. Lay a ruler to touch the arcs D and E, and a line drawn in that position is the parallel required.

This operation is mechanical.



156

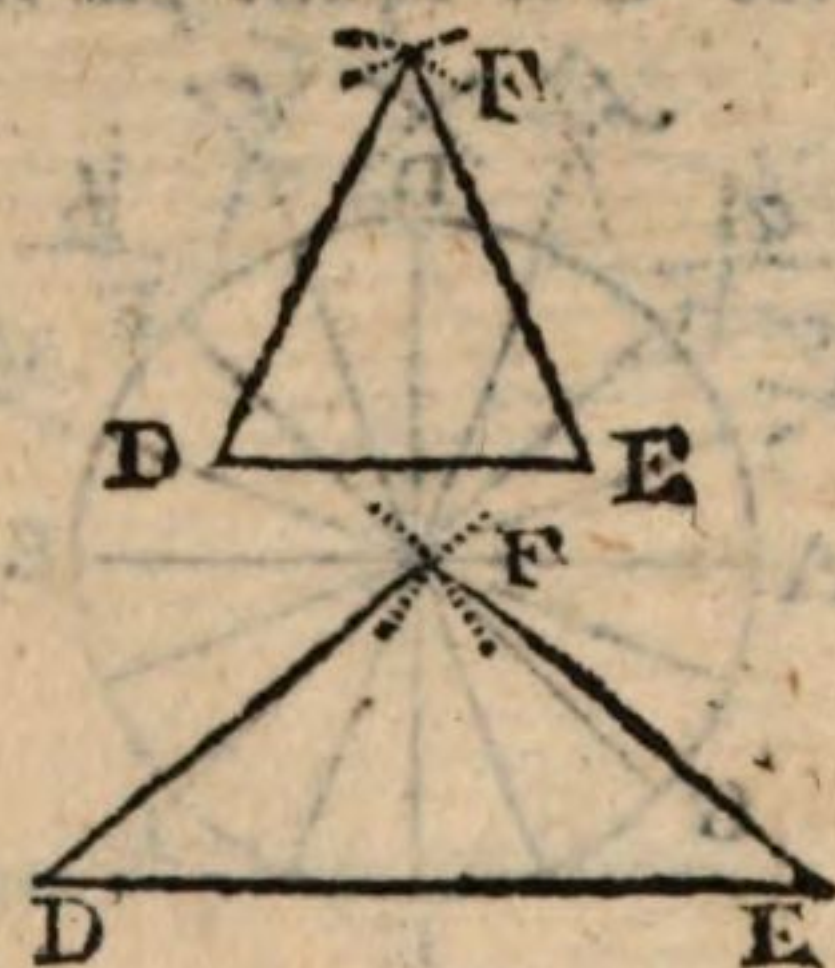
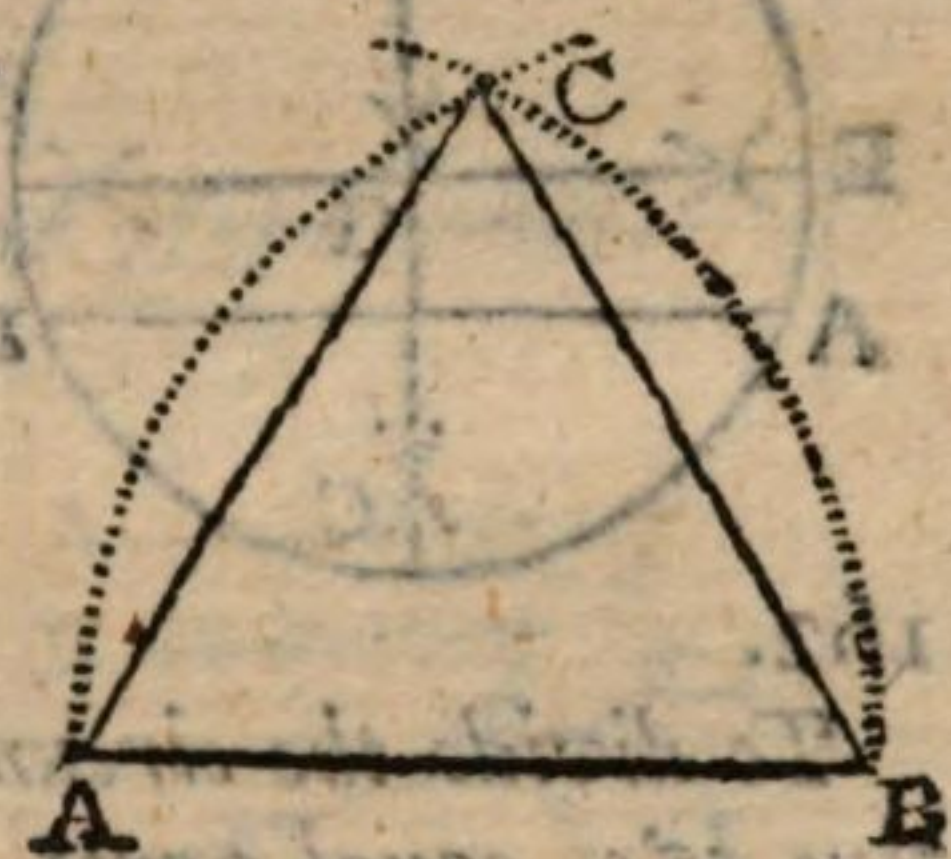
PROBLEM VIII.

Upon a given line AB, to make an equilateral triangle.

OPERATION, 1st. From the points A and B, with the radius AB, describe arcs cutting in C.

2d. Draw CA, CB, and the figure ABC is the triangle required.

The truth of this operation is evident; for the sides are radii of equal circles.



157. By a like operation, may an Isosceles triangle DEF be constructed on a given base DE, with the given equal legs DF, EF.

158.

PROBLEM IX.

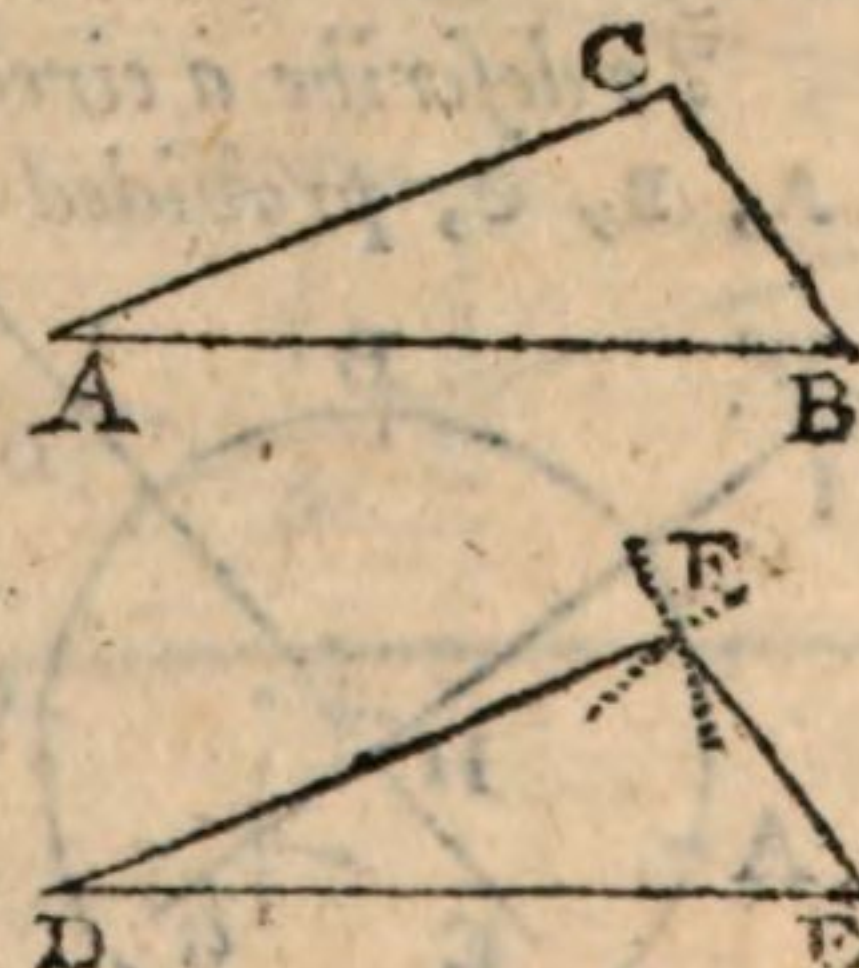
To make a right lined triangle whose sides shall be respectively equal to those of a given triangle ABC; or to three given lines, provided any two of them taken together are greater than the third.

OPERATION, 1st. Draw a line DE equal to the line AB.

2d. On D, with a radius equal to AC, describe an arc F.

3d. On E with a radius equal to BC, describe an arc cutting the arc F in F.

4th. Draw FD, FE, and the triangle DFE will be that required.



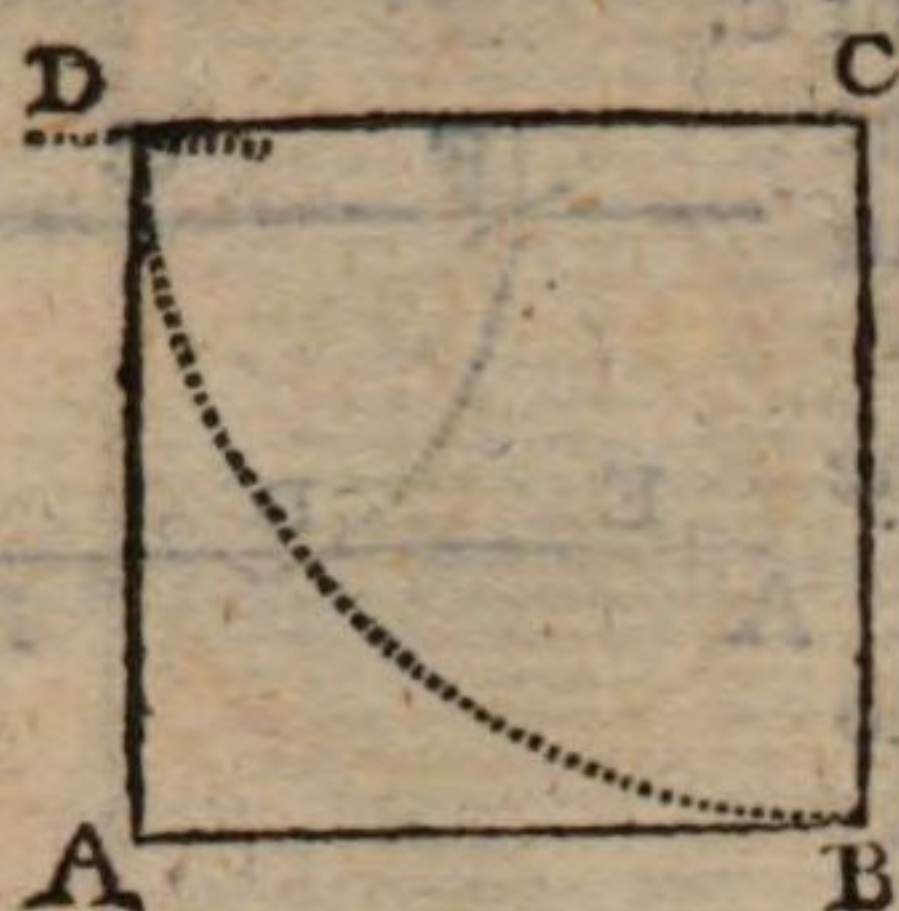
H

159. PRO-

159.

PROBLEM X.

Upon a given line AB, to describe a square.

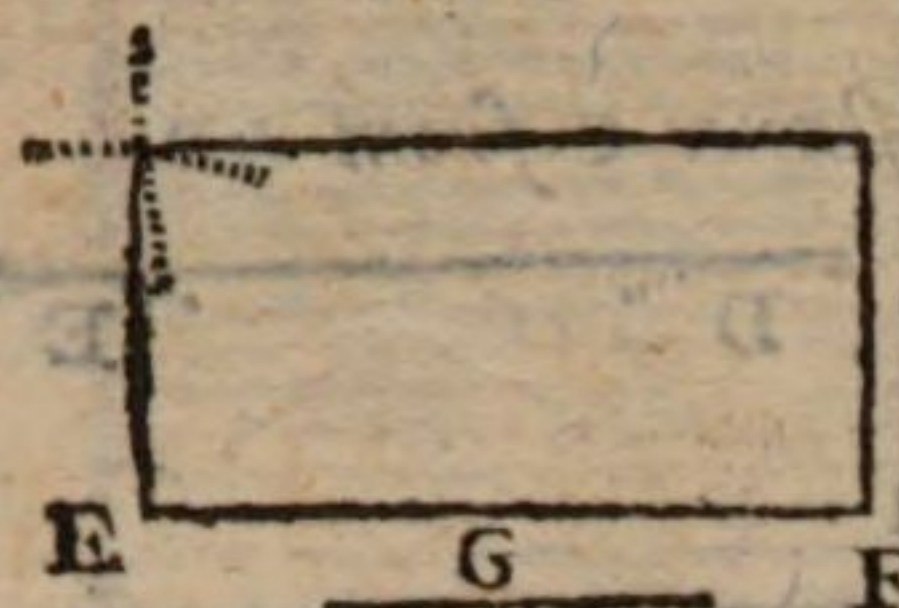


OPERATION, 1st. Draw BC perpendicular and equal to AB. (149).

2d. On A and C, with the radius AB, describe arcs cutting in D.

3d. Draw DC, DA; and the figure ABCD is the square required.

This depends on art. 191, 194, 185, 121.

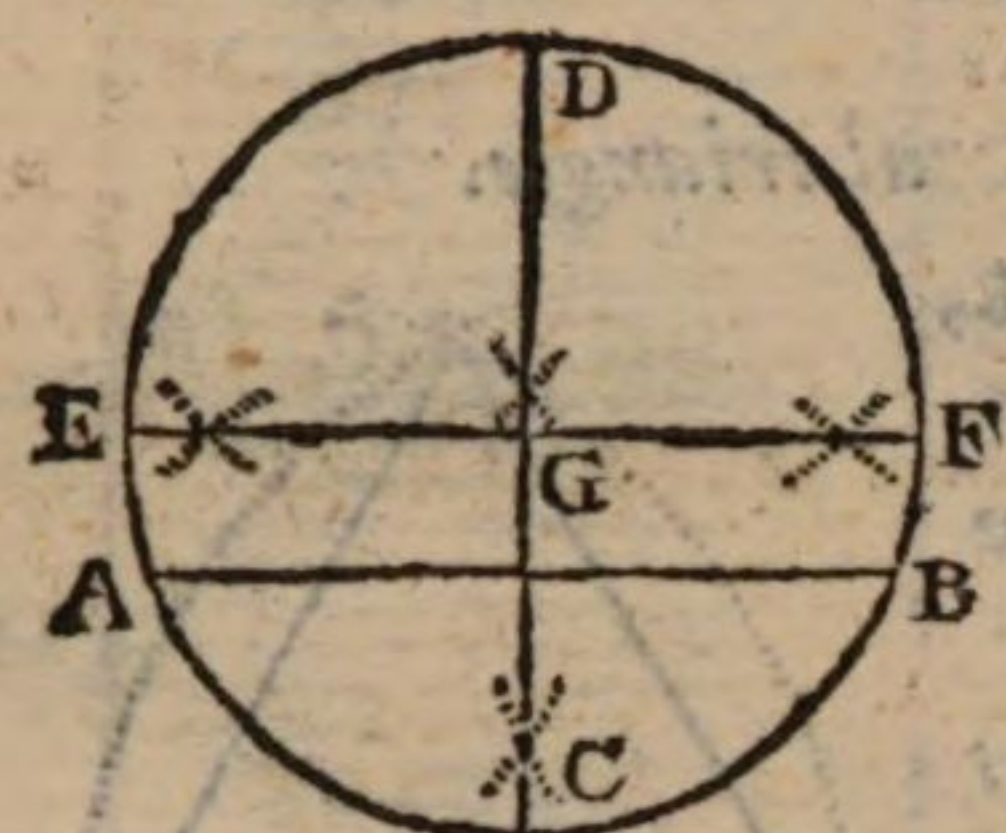


160. By a like operation a rectangle may be described, whose length shall be equal to the given line EF, and the breadth equal to the given line G.

161.

PROBLEM XI.

To find the centre of a circle.



OPERATION, 1st. Draw any chord AB.

2d. Bisect AB with the chord CD. (146).

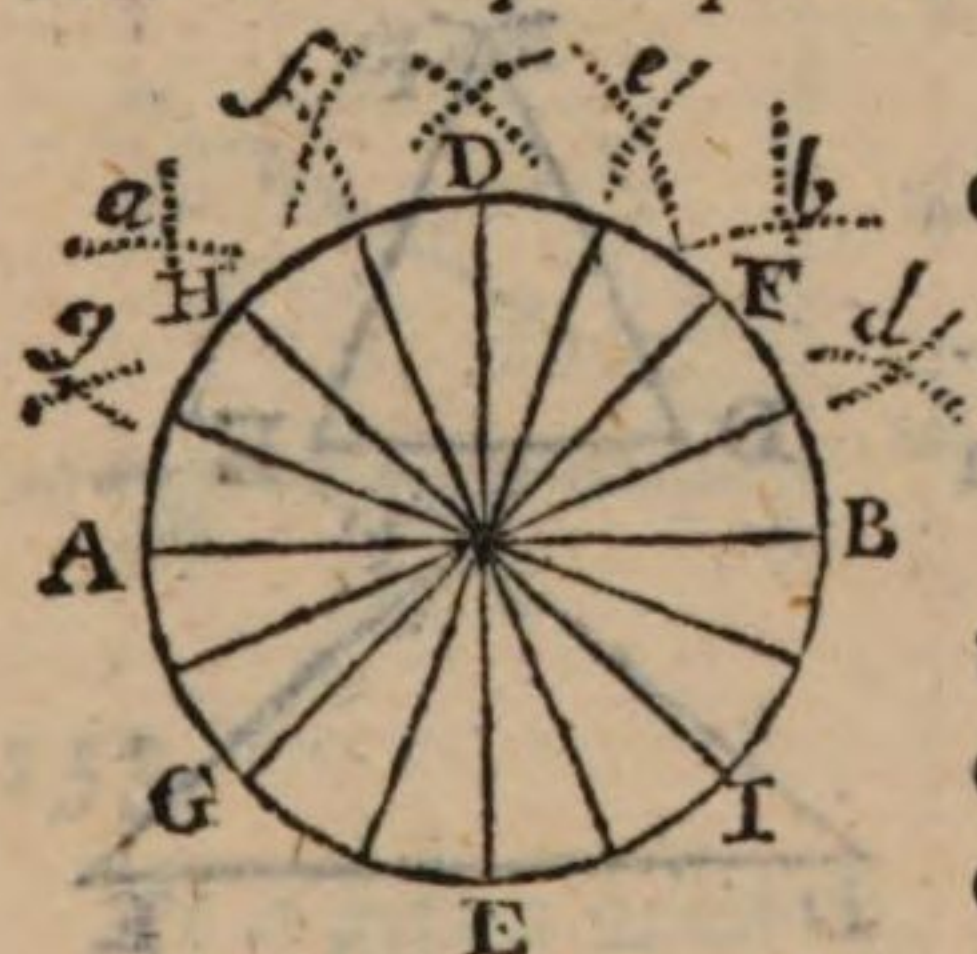
3d. Bisect CD with the chord EF, and their intersection G will be the centre required.

This depends on art. 208.

162.

PROBLEM XII.

To divide the circumference of a circle into two, four, eight, sixteen, thirty two &c. equal parts.



OPERATION, 1st. A diameter AB divides the circle into two equal parts.

2d. A diameter DE perpendicular to AB, divides the circumference into four equal parts.

3d. On A, D, B, describe arcs cutting in a, b; then by the intersections a, b and the centre, the diameters FG, HI, being drawn, divides it into eight equal parts.

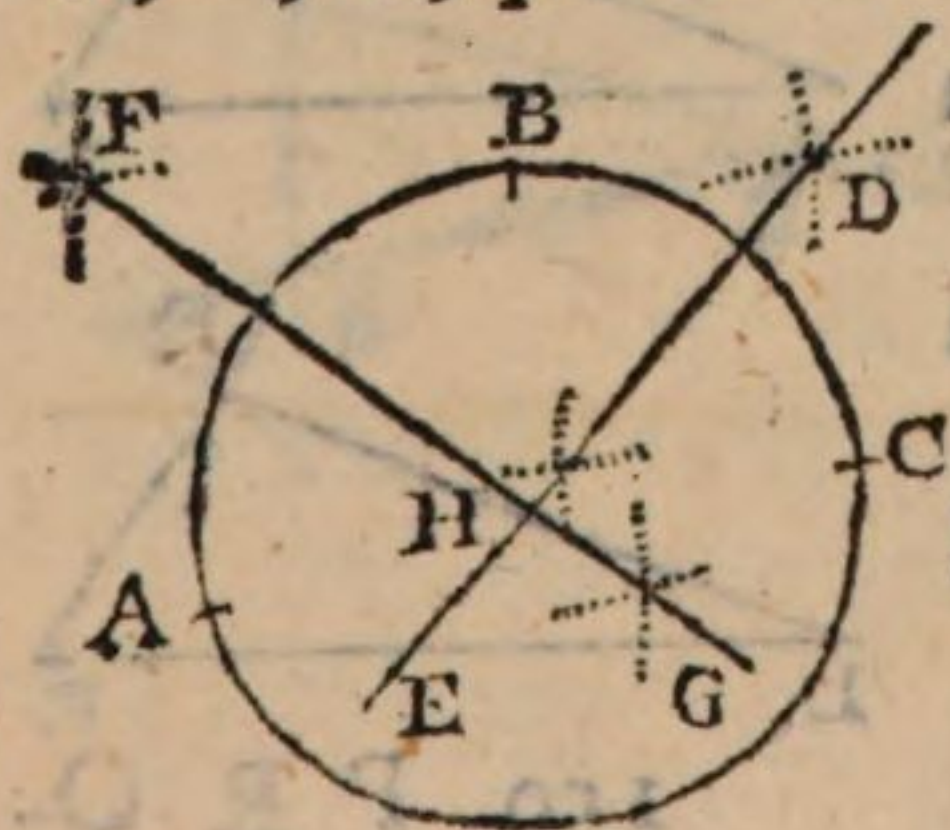
4th. On A, H, D, F, B, describe arcs cutting in g, f, e, d; by these and the centre, diameters being drawn, divides it into sixteen equal parts, &c.

For at each operation, the intercepted arcs are bisected.

163.

PROBLEM XIII.

To describe a circle, whose circumference shall pass thro' three given points A, B, C, provided they do not lie in one right line.



OPERATION, 1st. Bisect the distance CB with the line DE. (146).

2d. Bisect the distance AB with the line FG.

3d. On H, the intersection of these lines, with the distance to either of the given points, describe the circle required.

This depends on art. 208.

164.

164.

PROBLEM XIV.

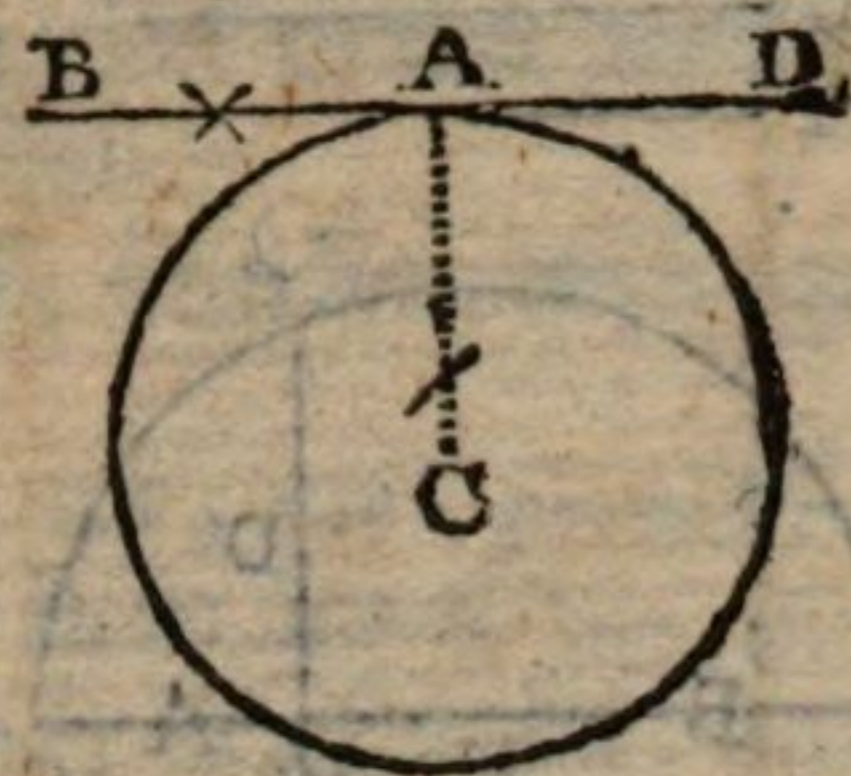
To draw a tangent to a given circle, that shall pass thro' a given point A.

When A is in the circumference of the circle.

OPERATION, 1st. From the centre c, draw the radius CA.

2d. Thro' A draw BD perpendicular to CA (149). and BD is the tangent required.

This depends on art. 209.



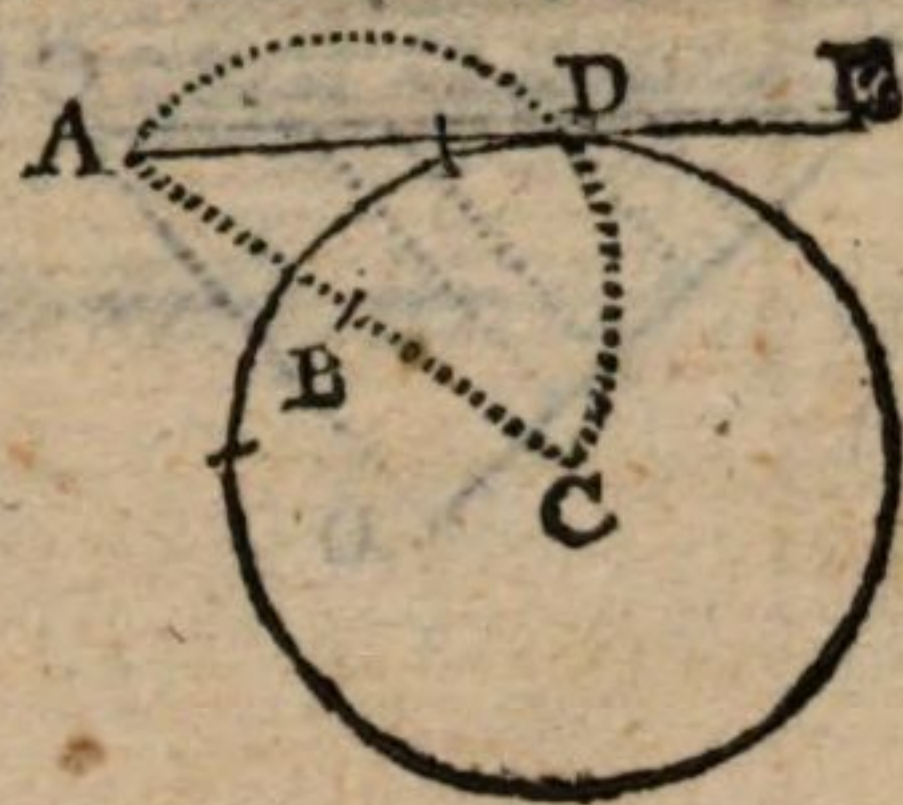
165. When the given point A, is without the given circle.

OPERATION, 1st. From the centre c draw CA, which bisect (146) in B.

2d. On B, with the radius BA, cut the given circumference in D.

3d. Thro' D, the line AE being drawn will be the tangent required.

This depends on art. 213, 209.



166.

PROBLEM XV.

To two given right lines A, B, to find D a third proportional.

OPERATION, 1st. Draw two right lines making any angle, and meeting in a.

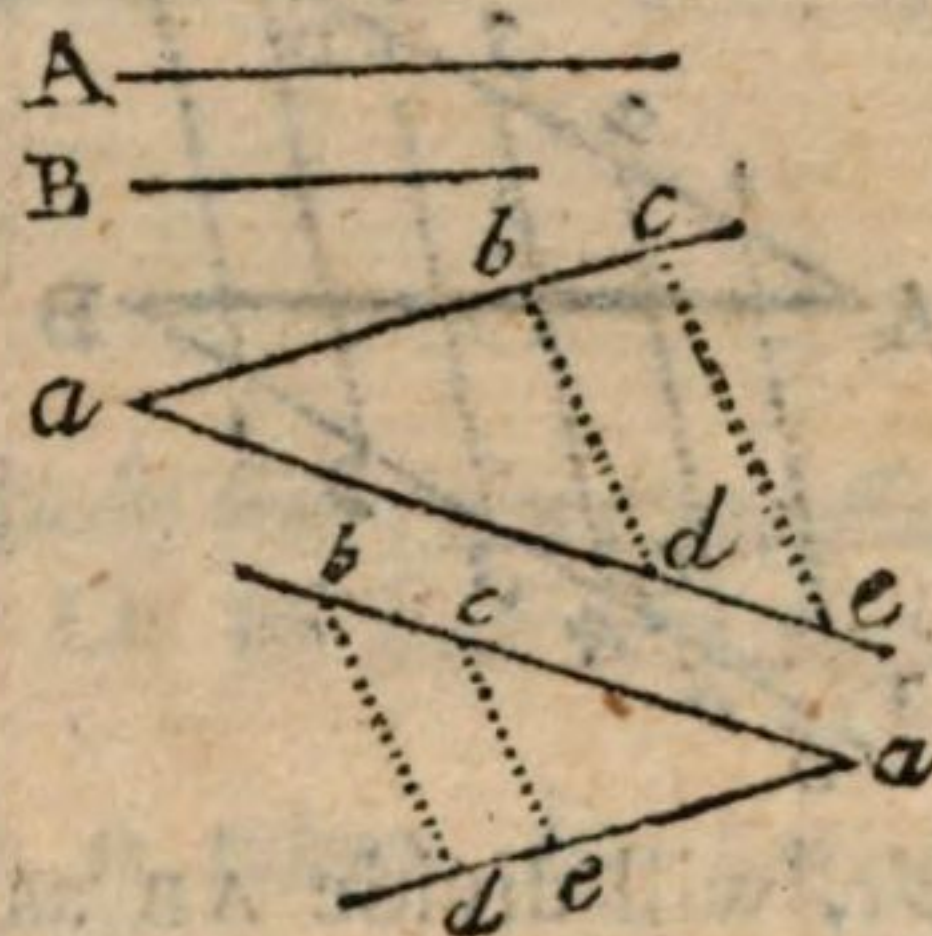
2d. In these lines, take $ab =$ first term, and ac , ad each equal to the second term.

3d. Draw bd , and thro' c draw ce parallel to bd ; then ae is the third proportional sought.

And $ab : ac :: ad : ae$. *

Or $A : B :: B : D$. And $B : A :: A : D$.

This depends on art. 248.



167.

PROBLEM XVI.

To three given right lines A, B, C, to find D a fourth proportional.

OPERATION, 1st. Draw two right lines making any angle, and meeting in a.

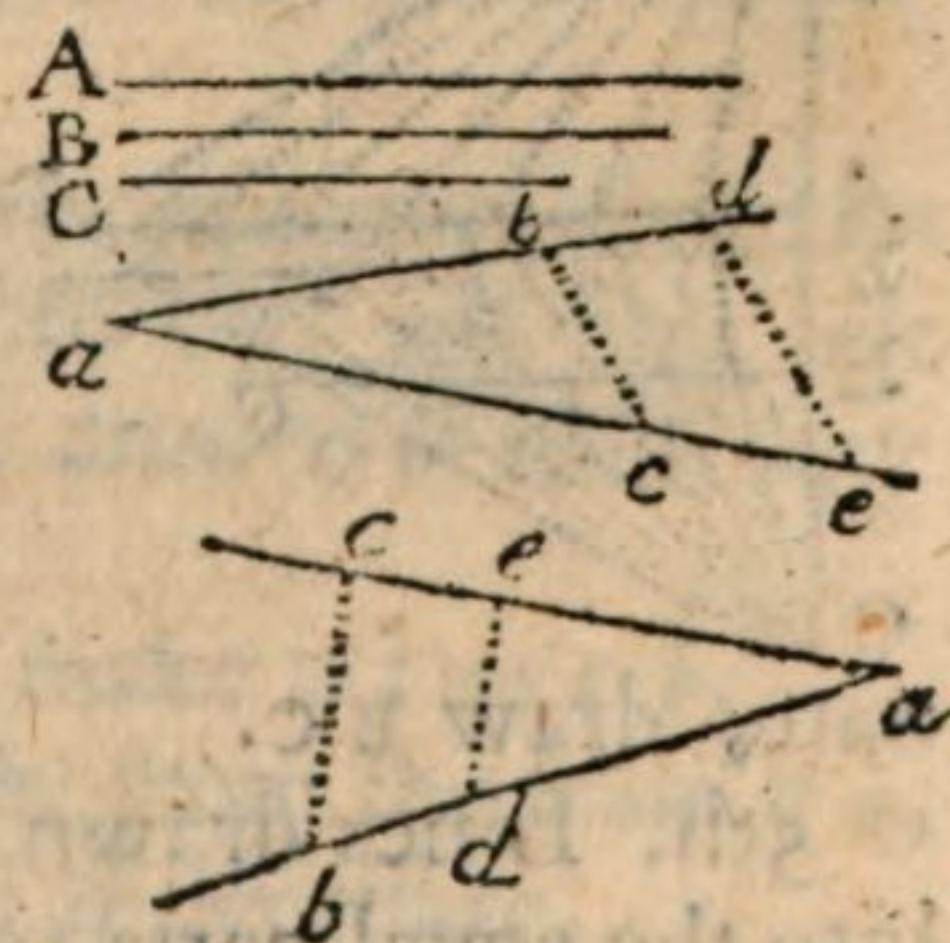
2d. In these lines take $ab =$ first term, $ac =$ second term, and $ad =$ third term.

3d. Draw bc , and parallel thereto thro' d draw de ; then ae is the fourth proportional required.

And $ab : ac :: ad : ae$.

Or $A : B :: C : D$. And $C : B :: A : D$.

This depends on art. 248.

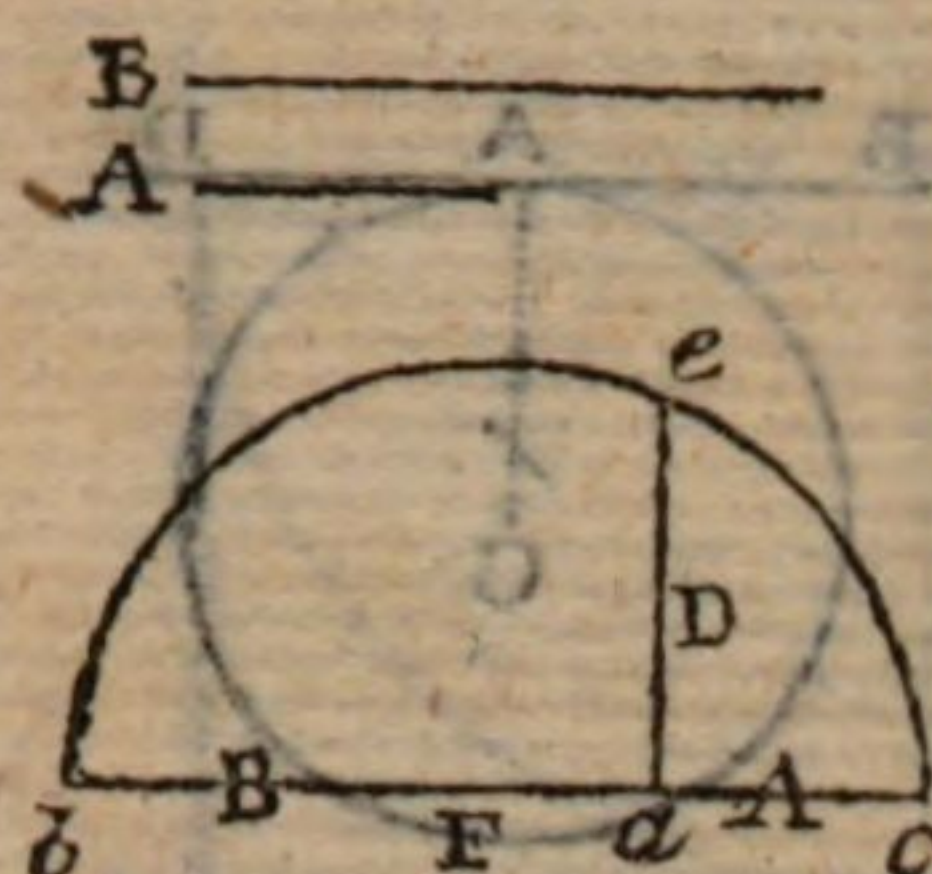


* And is thus read. ab is to ac so is ad to ae .
The first : stands for *is to*, the last : for *to*, and :: for *so is*.

168.

PROBLEM XVII.

Between two given right lines A, B, to find D, a mean proportional.



OPERATION, 1st. Draw a right line, in which take $ac = A$, $ab = B$.

2d. Bisect bc in F ; and on F , with the radius Fb , describe a circle bec .

3d. From a draw ae perpendicular to bc ; then ae is the mean proportional required.

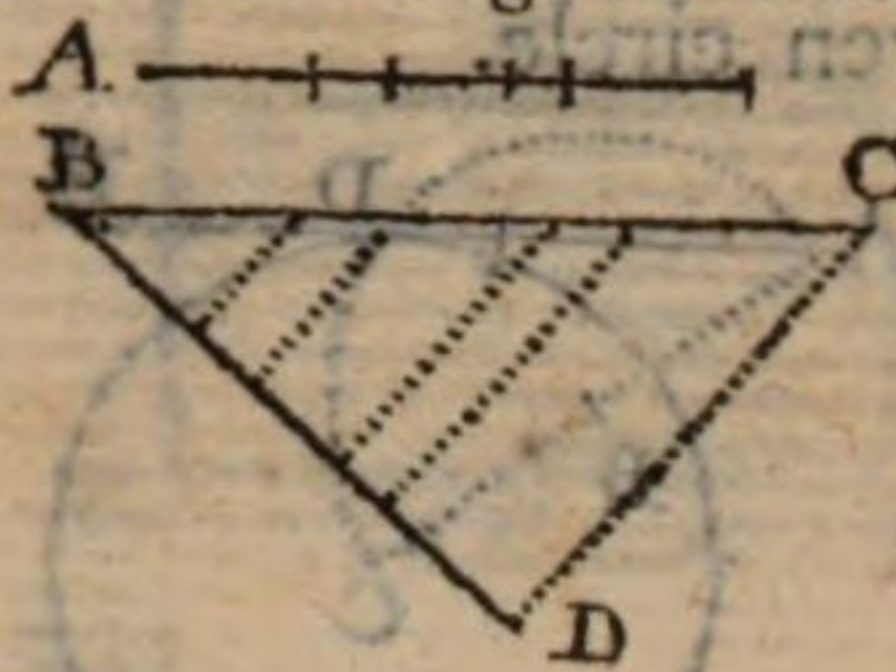
And $ac : ae :: ae : ab$. Or $A : D :: D : B$.

This depends on art. 254.

169.

PROBLEM XVIII.

To divide a given line BC in the same proportion as a given line A is divided.



OPERATION, 1st. From one end B of BC , draw BD making any angle with BC .

2d. In BD lay off from B , the several divisions of A , so BD will be equal to A .

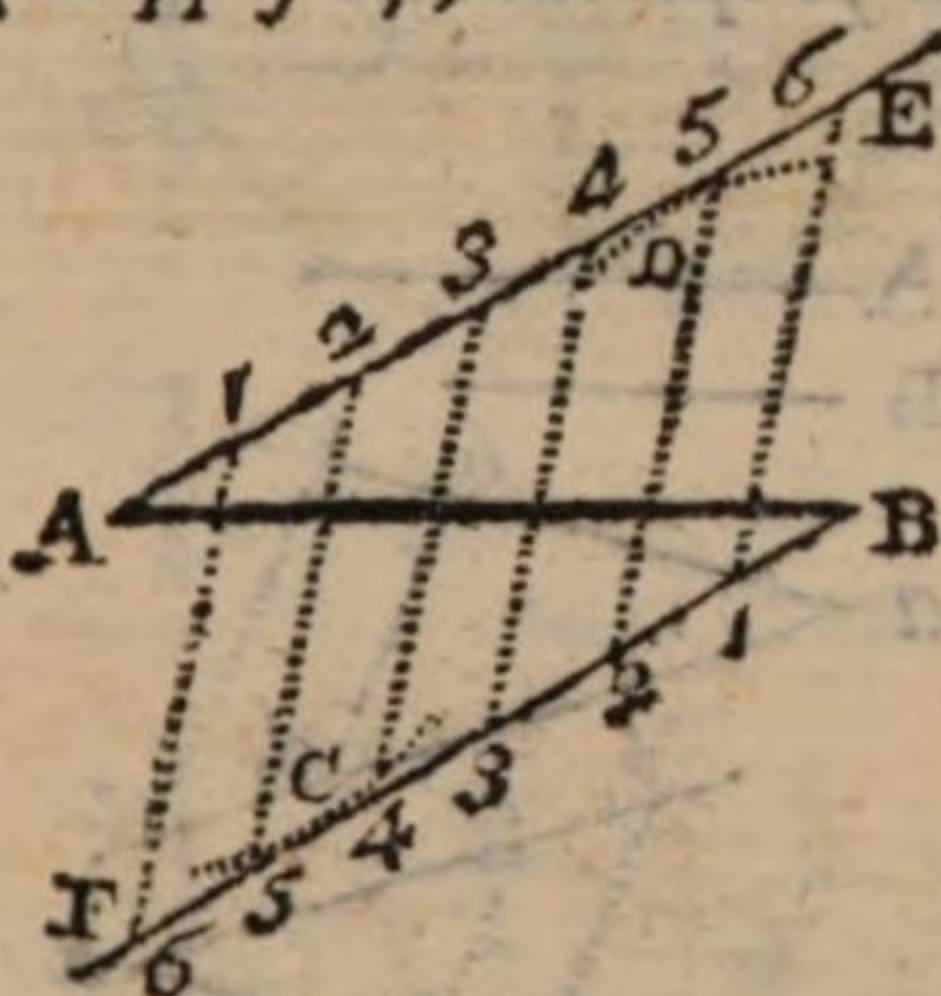
3d. Draw CD ; then lines drawn parallel to CD thro' the several divisions of BD , will divide the line BC in the manner required.

This depends on art. 248.

170.

PROBLEM XIX.

To divide a given right line AB into a proposed number of equal parts (Suppose 7).



OPERATION, 1st. From the ends A, B , with the same radius, describe the arcs C, D ; and from A and B lines drawn to touch these arcs, as AE, BF , will be parallel. (155).

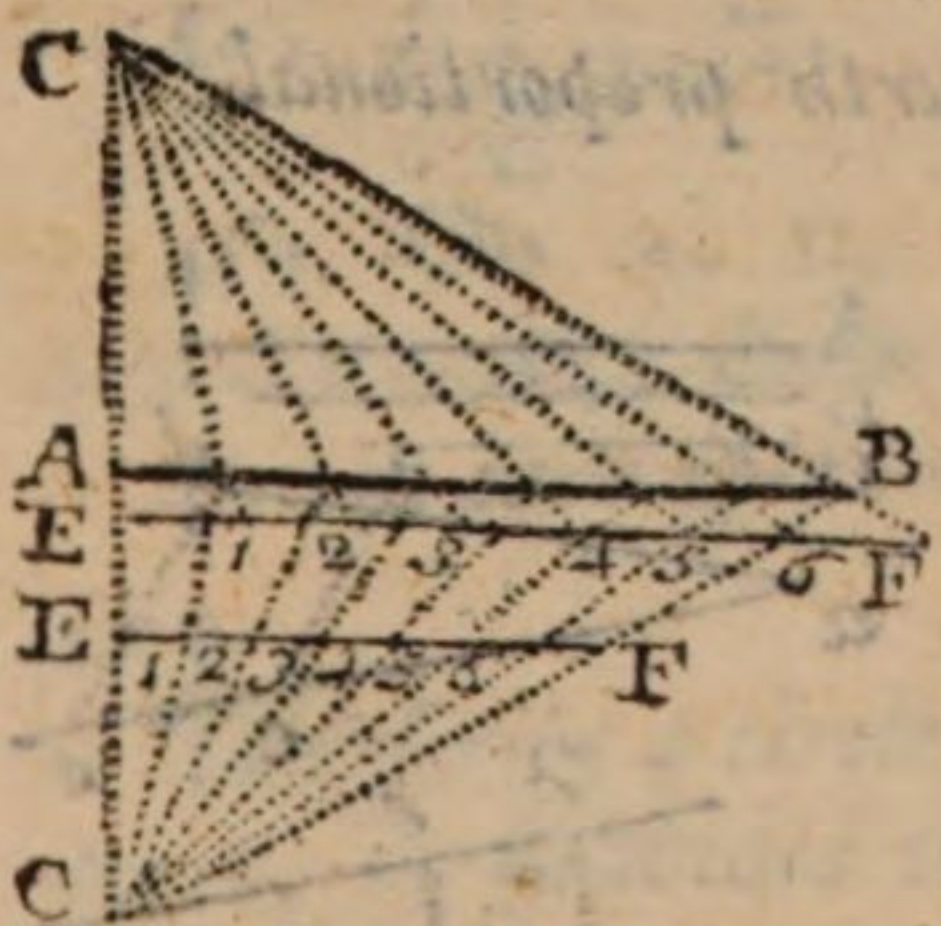
2d. In each of the lines AE, BF , beginning at A and B , take of any length, as many equal parts less one as AB is to be divided into, viz. 1, 2, 3, 4, 5, 6.

3d. Lines drawn from 1 to 6, 2 to 5, 3 to 4, &c. will divide AB as was required.

This depends on art. 248.

171.

Another Method.



OPERATION, 1st. Thro' one end A , draw a line CC nearly perpendicular to AB .

2d. Draw EF parallel to AB , at any convenient distance.

3d. In EF take of any length, as many equal parts as AB is to be divided into; as 1, 2, 3, 4, 5, 6, to F .

4th. Thro' B , and F where the divisions termi-

nate, draw BC .

5th. Lines drawn from C thro' the several divisions of EF , will cut AB into the equal parts required.

Note. If the divisions from E to F chance to be less than AB , the point C , and the line EF will be on the same side of AB ; But if greater, C falls on the contrary side.

172.

PROBLEM XX.

To make scales of equal parts.

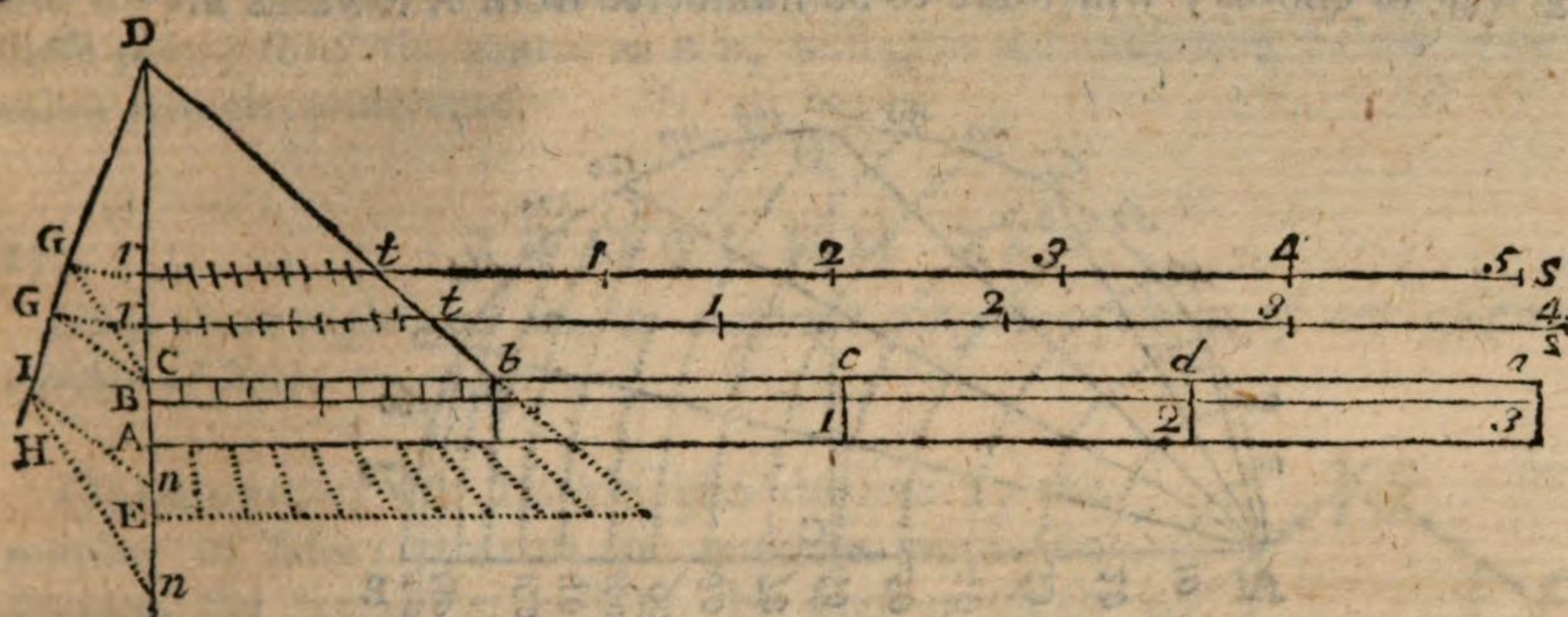
OPERATION, 1. Draw three lines A, B, C, parallel to one another, and at convenient distances, such as are here expressed.

2d. In the line A, take the equal parts Ab , bc , cd , da , &c. each equal to some proposed length.

3d. Thro' A draw the line DE perpendicular to Aa; and parallel to DE, thro' the several points b , c , d , a , &c. draw lines across the three parallels A, B, C; then are the spaces or distances Ab , bc , cd , &c. called the primary divisions.

4th. Divide the left hand space into 10 equal parts (171), and thro' these points let lines parallel to DE be drawn across the parallels BC; and the primary division Ab , will be parted into 10 equal spaces called subdivisions.

5th. Number the primary divisions from the left towards the right, beginning at c , and the scale is constructed.



Such scales are useful for constructing of figures whose sides are expressed in measures of length; as feet, yards, miles, &c. Or to find the measures of the lengths of lines in a given figure.

Thus a line of 36, or of 360, feet, yards, &c. is taken, by setting one point of the compasses on the third primary division, and extending the other point to the sixth subdivision: And so of others.

In these scales 'tis usually supposed that an inch is divided into some number of such parts, as are expressed by the subdivisions.

173. *To find the divisions of a scale of equal parts, when any given number of them are to make an inch.*

OPERATION, 1st. Make a scale ca , where the primary divisions shall be each one inch; let DC be at right angles to ca , and the left hand space cb be divided into 10 equal parts, and draw Db from any point D.

2d. Draw DH , making with DC any angle; and make $DI = cb$.

3d. Take the number of parts proposed in an inch, from the scale ca , and lay them from D to n , in the line DC , continued if necessary.

4th. Draw nI , and CG parallel to nI ; and make $Dr = DG$.

5th. Thro' r draw rs ; cutting Db in t ; then rt will be one of the primary divisions containing 10 of the parts the inch was to be divided into.

6th. Lines drawn from D to the divisions of cb , divides rt into 10 equal parts.

174. PROBLEM XXI.

To divide the circumference of a circle into degrees; and thence to make a scale of chords.

OPERATION, 1st. Describe the semicircle ABD , whose centre is C ; and draw CD at right angles to AB .

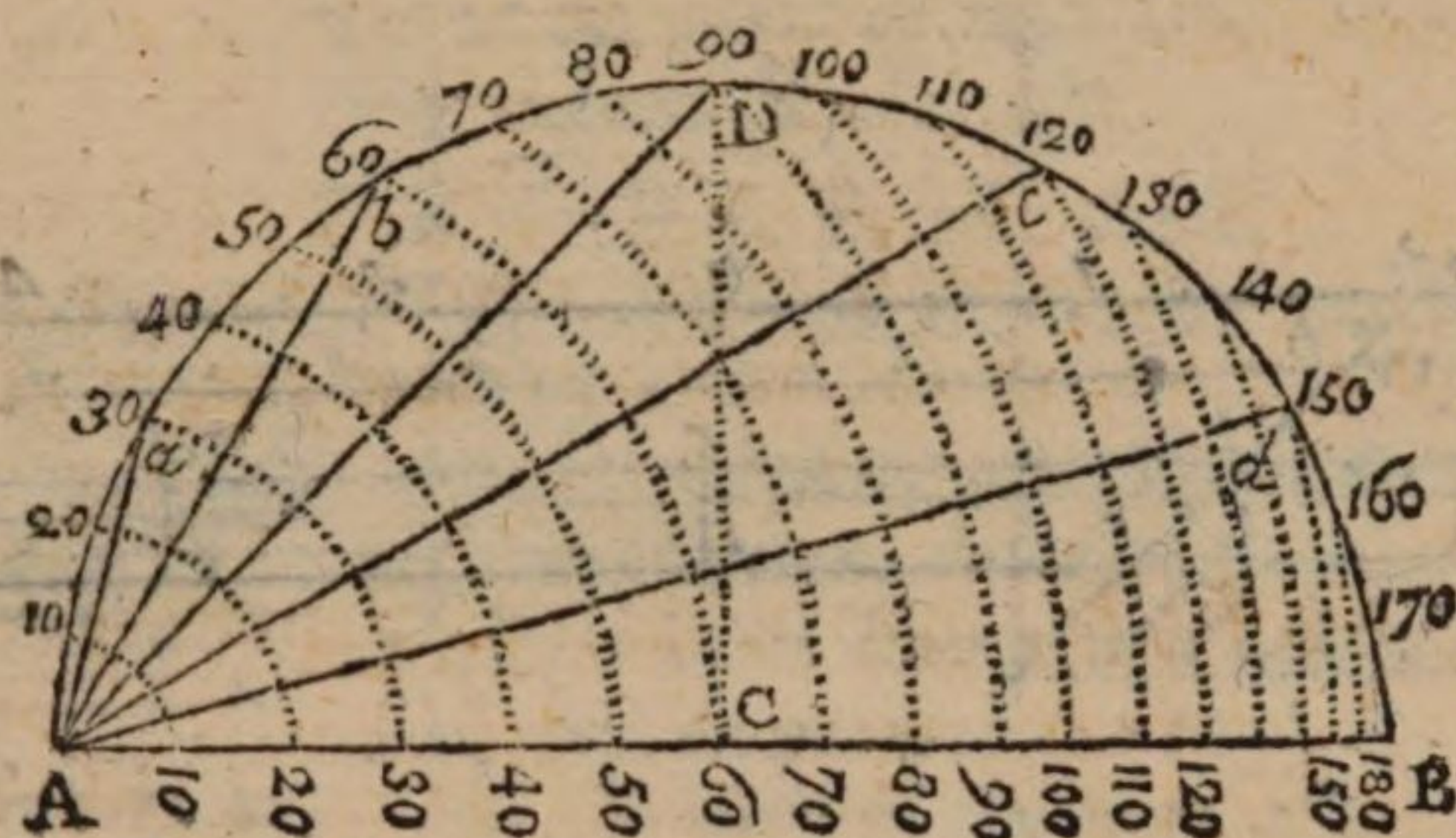
2d. Trisect the angles ACD , DCB , in the points $a, b; c, d$; (152), then by trials, divide the arcs Aa, ab, bD, Dc, cd, dB , each into three equal parts, and the semicircumference will be divided into 18 equal parts, of 10 degrees each.

3d. These arcs being bisected, will give arcs of 5 degrees.

4th. And these arcs being divided into 5 equal parts, by trials, will give arcs of 1 degree each.

The like may be done with the whole circumference.

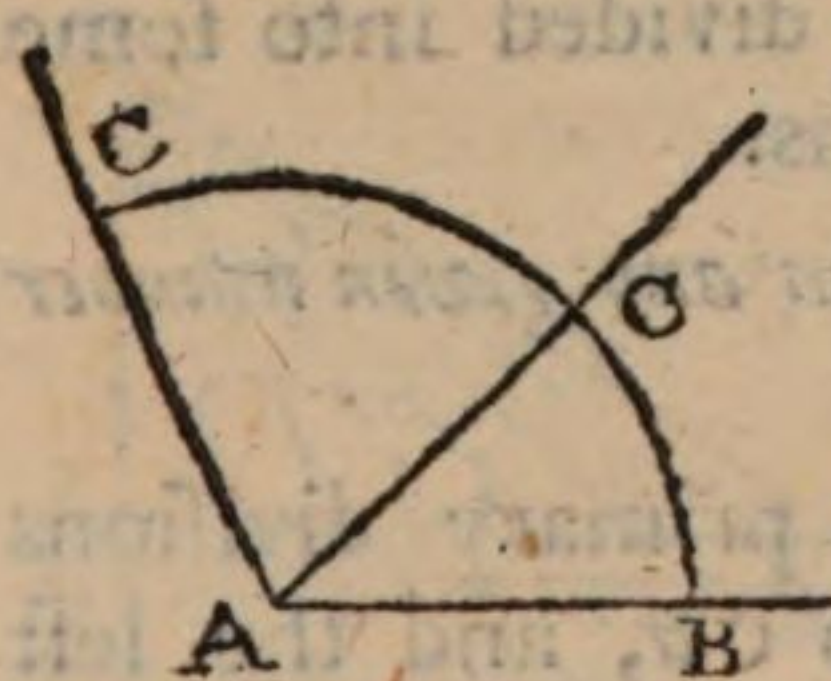
5th. The chords of the arcs Ad, Ac, AD, Ab, Aa , and of every other arc, being applied from A on the diameter AB , will divide AB into a scale of chords; which are to be numbered from A towards B .



A scale of chords is useful for constructing an angle of a given number of degrees: And for finding the measure of a given angle.

175. PROBLEM XXII.

To make an angle of a proposed number of degrees.



OPERATION, 1. Take the first 60 deg. from the scale of chords, and with this radius describe an arc BC , whose centre is A .

2d. Take the chord of the proposed number of degrees from the scale, reckoning from its beginning, and apply this distance to the arc BC , from B to c .

3d. Lines drawn from A , thro' the points B and c , will form an angle BAC , whose measure is the degrees proposed.

When a given angle BAC is to be measured.

From the angular point A , with the chord of 60 degrees, describe the arc BC , cutting the legs in the points B and c .

Then the distance BC applied to the chords, from the beginning, will shew the degrees which measure the angle BAC .

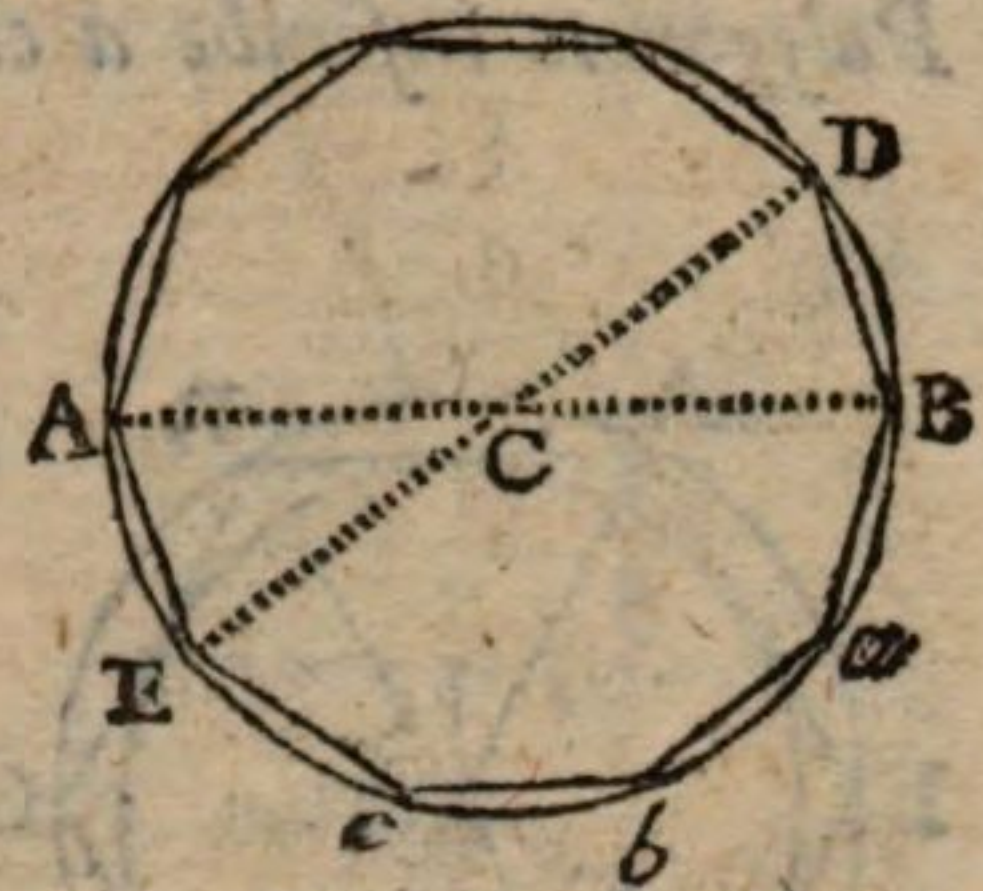
176.

PROBLEM XXIII.

In a given circle to inscribe a regular polygon, the number of sides being given,

OPERATION, 1st. Divide 360 degrees by the number of sides, and the quotient will be the degrees which measure the angle at the centre of the circle subtended by a side of the *polygon*.

2d. Draw the radius CB , make an angle BCD equal to those degrees, and draw the chord DB ; then will DB be the side of the polygon required; which applied to the circumference from B to a , a to b , b to c &c. will give the points to which the sides of the polygon are to be drawn.



If the polygon has an even number of sides; draw the diameter AB ; and divide half the circumference, as before; then lines drawn from these points thro' the centre as ED , will give the remaining points in the other semicircle.

177.

PROBLEM XXIV.

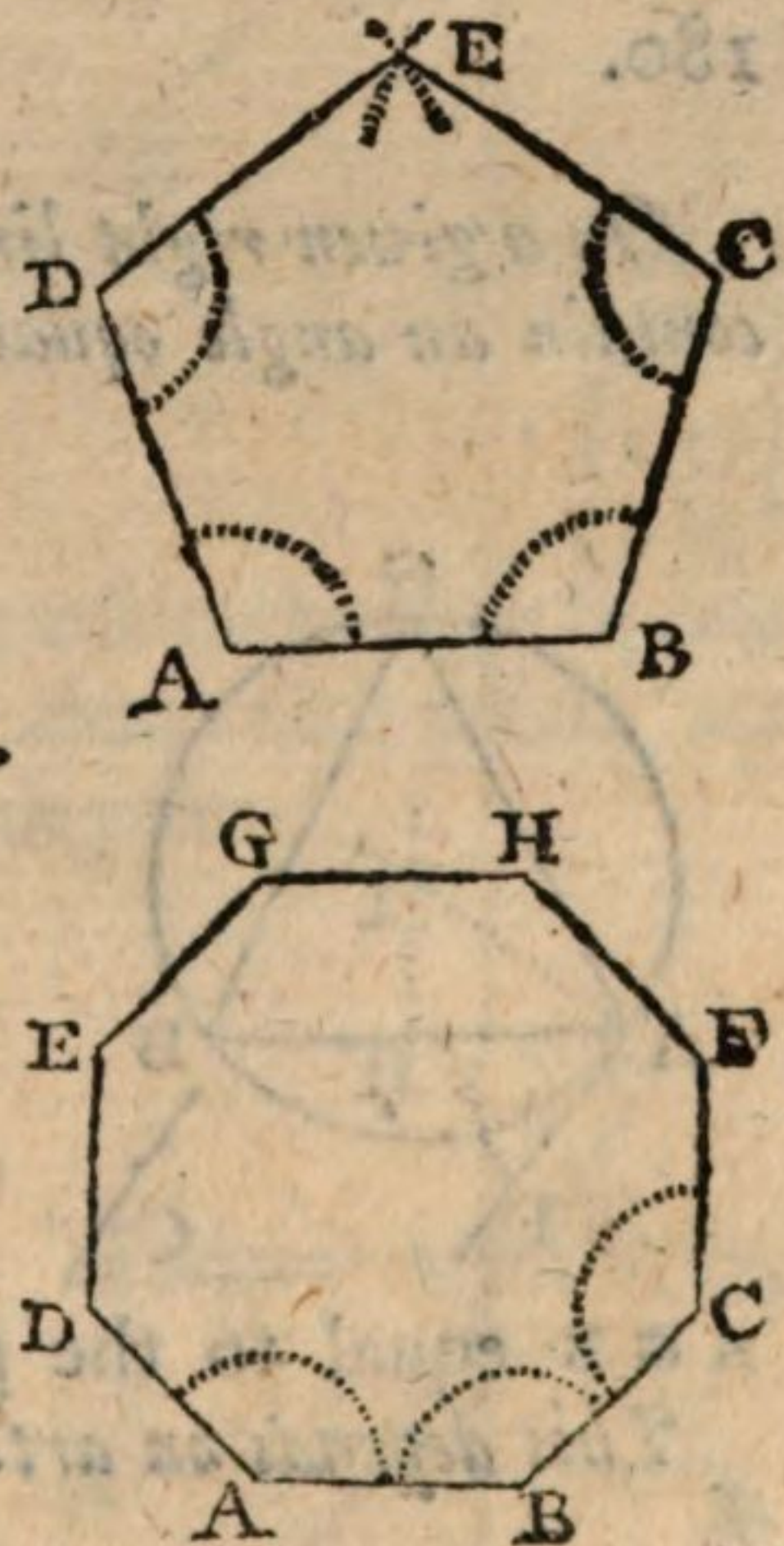
On a given right line AB , to construct a regular polygon of any assigned number of sides.

OPERATION, 1st. Divide 360 degrees by the number of sides; subtract the quotient from 180 degrees, the remainder will be the degrees which measure the angle made by any two adjoining sides of that polygon, and is called the angle of the polygon.

2d. At the ends A, B , of the line AB , make angles ABC, BAD , equal to the angle of the polygon.

3d. Make AD, BC , each equal to AB .

4th. At the points C, D , make angles equal to that of the polygon as before; and let the sides including those angles be each equal to AB ; and thus proceed until the polygon is constructed.



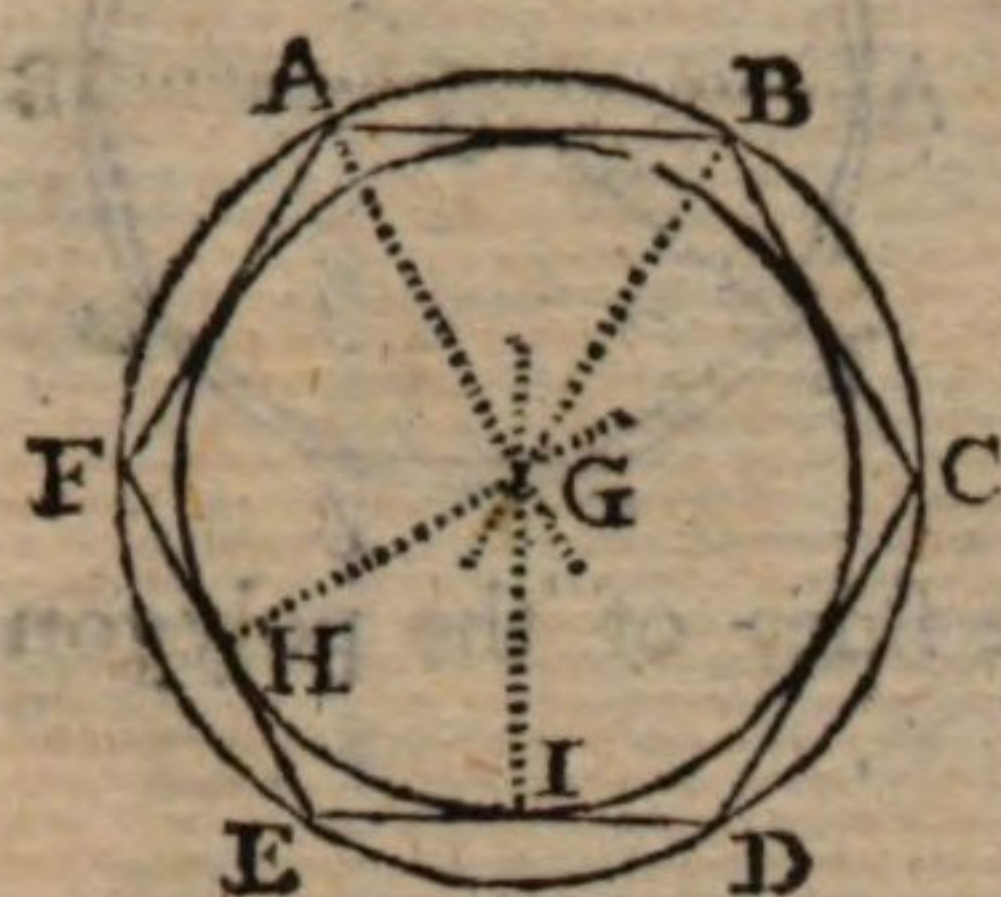
In figures of any number of sides, the two last DE, CE , or EG, HG , are readiest found by describing arcs from C and D , or from E and H , with the radius AB , intersecting in E , or in G .

In figures of an even number of sides, having drawn half the number, AD, AB, BC, CF , by means of the angles; the remaining sides may be found by drawing thro' the points D and F , the lines DE, FH , parallel and equal to their opposite sides CF, AD ; and so of the rest.

178.

PROBLEM XXV.

About a given Regular Polygon, to circumscribe a circle: Or, within that Polygon to inscribe a circle.



OPERATION, 1st. Bisect any two angles FAB, CBA, with the lines AG, BG, and the point G where they intersect one another will be the centre of the polygon.

2d. A circle described from G, with the radius GA, will circumscribe the given polygon.

179. Or, 1st. Bisect any two sides FE, ED, in the points H and I; and draw HG, IG, at right angles to FE, ED; then the point G where they intersect each other, will be the centre of the polygon.

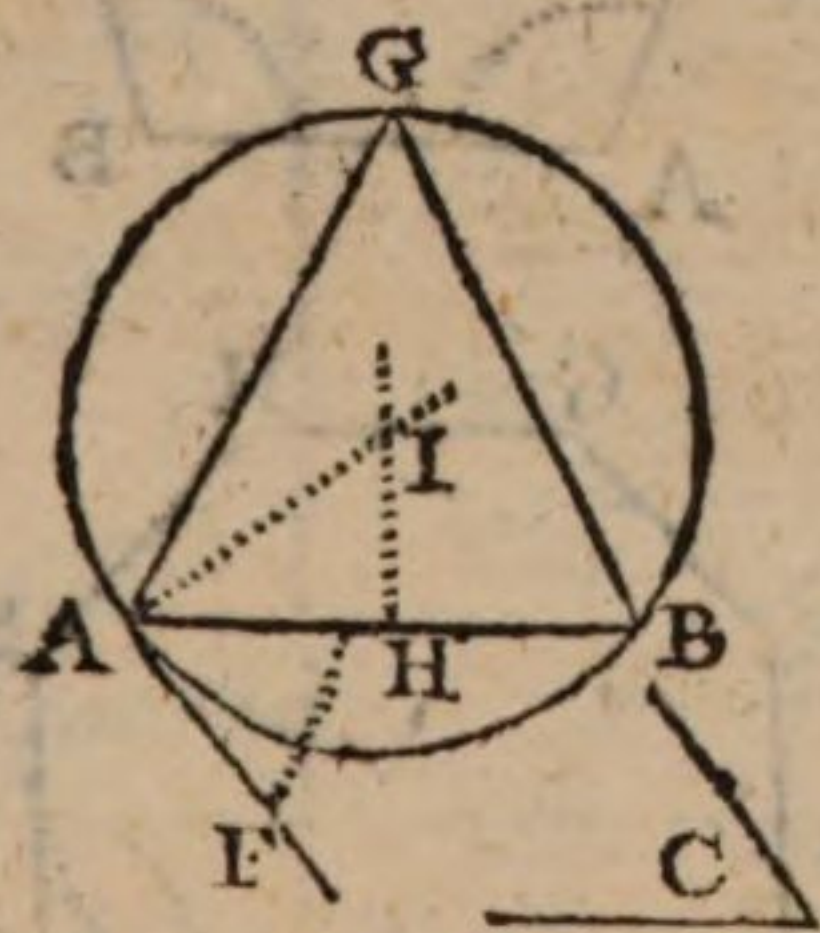
2d. A circle described from G, with the radius GH, will be inscribed in the given polygon.

This depends on art. 209.

180.

PROBLEM XXVI.

On a given right line (AB), to describe a segment of a circle, that shall contain an angle equal to a given right lined angle (C).



OPERATION, 1st. Make an angle BAF equal to the given angle C. (153)

2d. From H, the middle of AB, draw HI at right angles to AB, and from A, draw AI at right angles to AF, cutting HI in I.

3d. From I, with the radius IA, describe a circle.

Then will the segment AGB contain an angle AGB equal to the given angle C.

This depends on art. 208, 209, 215.

SECTION

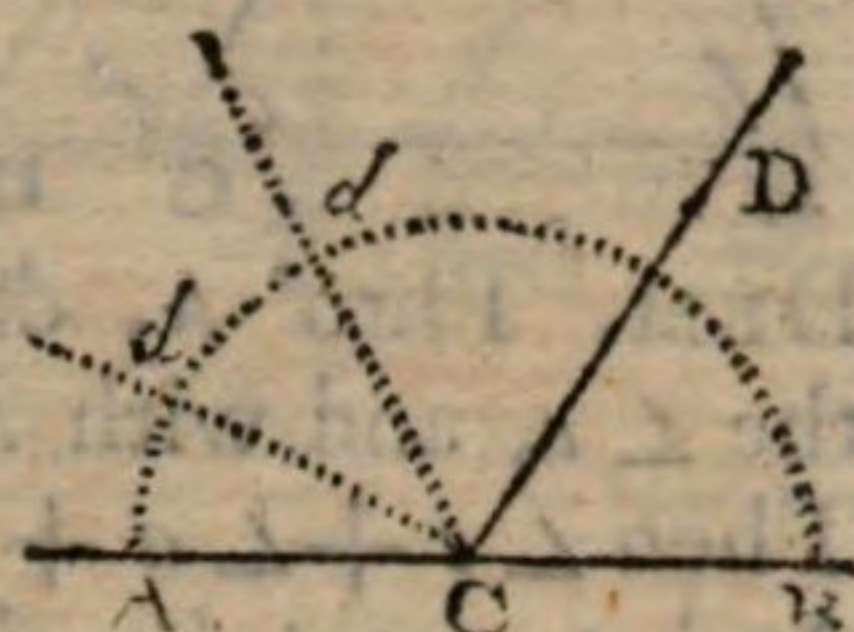
SECTION III.

GEOMETRICAL THEOREMS.

OF PLANES.

181. THEOREM I.

When one right line (CD) stands upon another right line (AB), they make two angles (BCD, ACD) which together are equal to two right angles.

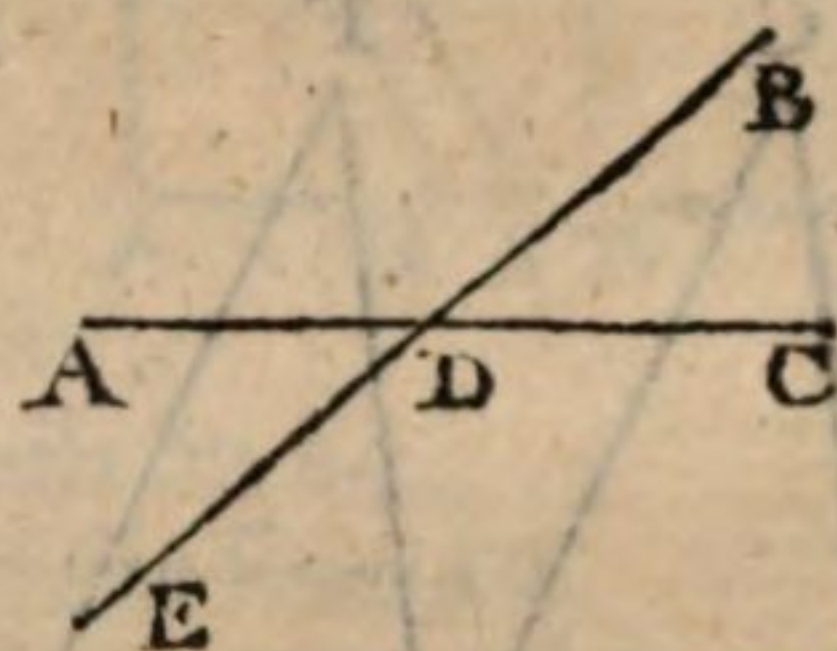


DEMONSTRATION. For describing a semicircle ADB, on C. (136)
 Then the arc DB measures the angle BCD. (106)
 And the arc DA measures the angle ACD. (106)
 But the arcs DB and AD together measure two right angles. (104, 107)
 Therefore BCD and ACD together, are equal to two right angles. (141)

182. COROLLARY. Hence if ever so many right lines (CD) stand on one point (C), on the same side of another right line (AB); the sum of all the angles are equal to two right angles; or are measured by 180 degrees.

183. THEOREM II.

If two right lines (AC, EB) intersect each other (in D), the opposite angles are equal, viz. $\angle CDB = \angle ADE$, also $\angle CDE = \angle ADB$.

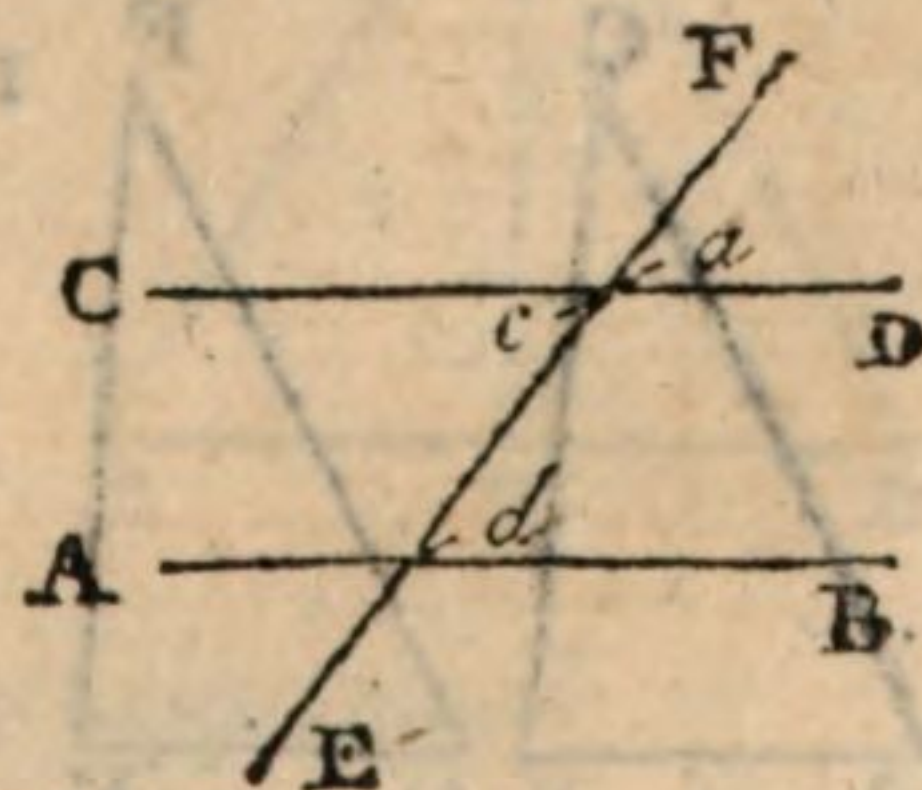


DEM. For $\angle ADE + \angle ADB =$ two right angles. (181)
 And $\angle CDB + \angle ADB =$ two right angles. (181)
 Therefore $\angle ADE + \angle ADB = \angle CDB + \angle ADB$. (137)
 Consequently $\angle ADE = \angle CDB$. (139)

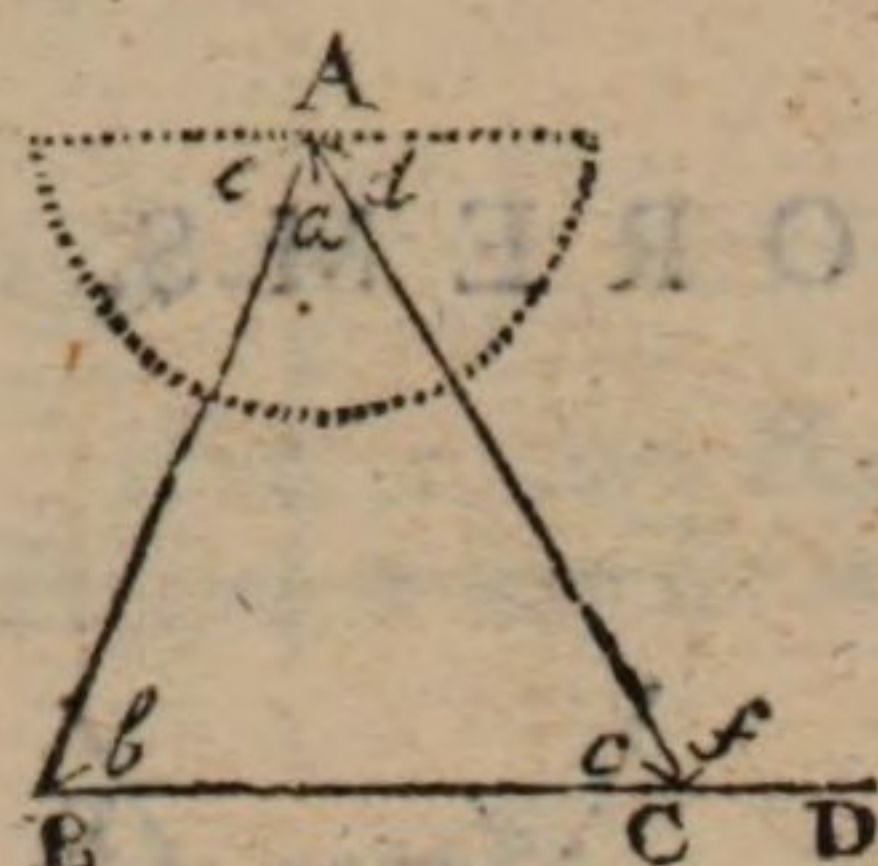
184. COROL. Hence if ever so many right lines cross each other in one point, the sum of all the angles which they make about that point, are equal to four right angles; or are measured by 360 degrees.

185. THEOREM III.

If a right line (FE) cut two parallel right lines (AB, CD); then is the outward angle (a) equal to the inward and opposite angle (d); and the alternate angles (c, d) are equal: and the contrary.



DEM. Because CD and AB are parallel by supposition:
 Then FE has the same inclination to CD and AB. (144)
 And this inclination is expressed by the $\angle a$ or $\angle d$: (105)
 Therefore the outward $\angle a$ is equal to the inward and opposite $\angle d$.
 Now the $\angle a$ is equal to the $\angle c$, (183)
 And since the $\angle a$ is equal to the $\angle d$;
 Therefore the alternate angles c and d are equal. (127)



186. THEOREM IV.

In any right lined triangle (ABC), the sum of the three angles (a, b, c,) are equal to two right angles : And if one side (BC) be continued, the outward angle (f) is equal to the sum of the two inward and opposite angles (a, b).

DEM. Thro' A, draw a right line parallel to BC. (154) making with AB the $\angle e$, and with AC the angle d .

Then $\angle e + \angle a + \angle d =$ two right angles. (182)

And $\angle e = \angle b$; also $\angle d = \angle c$. (185)

Therefore $\angle b + \angle a + \angle c = \angle e + \angle a + \angle d$. (138)

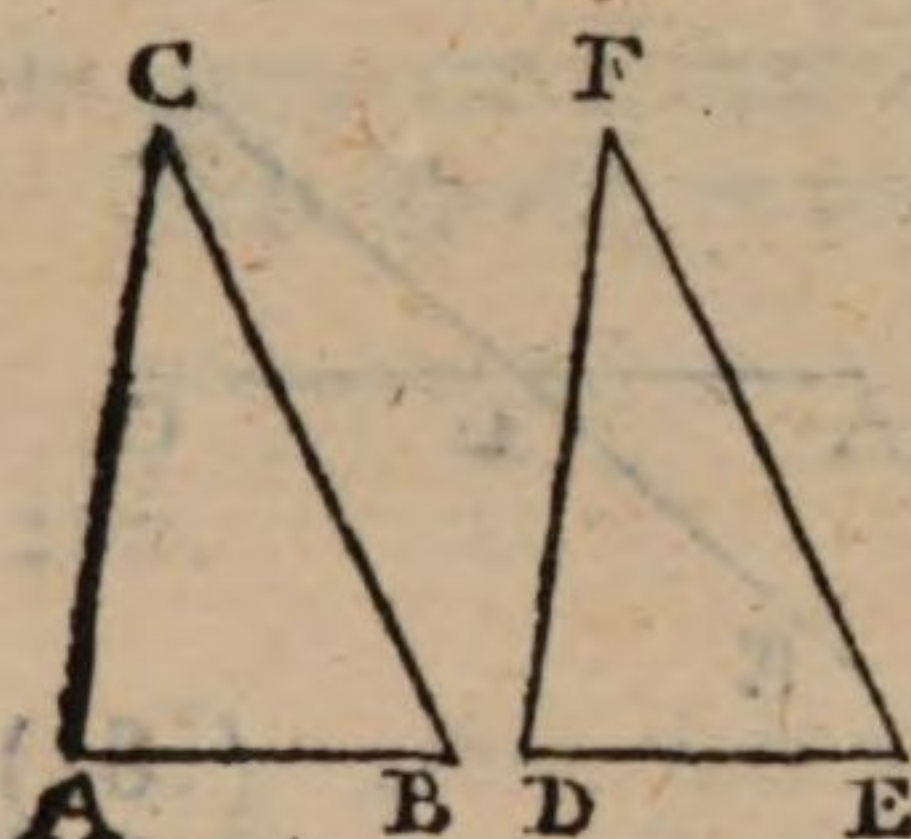
Consequently $\angle b + \angle a + \angle c =$ two right angles. (137)

Also $\angle c + \angle f =$ two right angles. (181)

Therefore $\angle f = \angle a + \angle b$. (137)

187. Hence, if one angle is right or obtuse, each of the others is acute.

188. If two angles of one triangle are equal to two angles of another triangle, the remaining angles are equal. And if one angle in one triangle is equal to one angle in another triangle, then is the sum of the remaining angles in one, equal to the sum of the remaining angles in the other.



189. THEOREM V.

If two sides (AB, AC) and the included angle (A) in one triangle (ABC), are respectively equal to two sides (DE, DF) and the included angle (D) of another (DEF), each to each; then are those triangles congruous.

DEM. Apply the point D to the point A, and the line DE to AB.

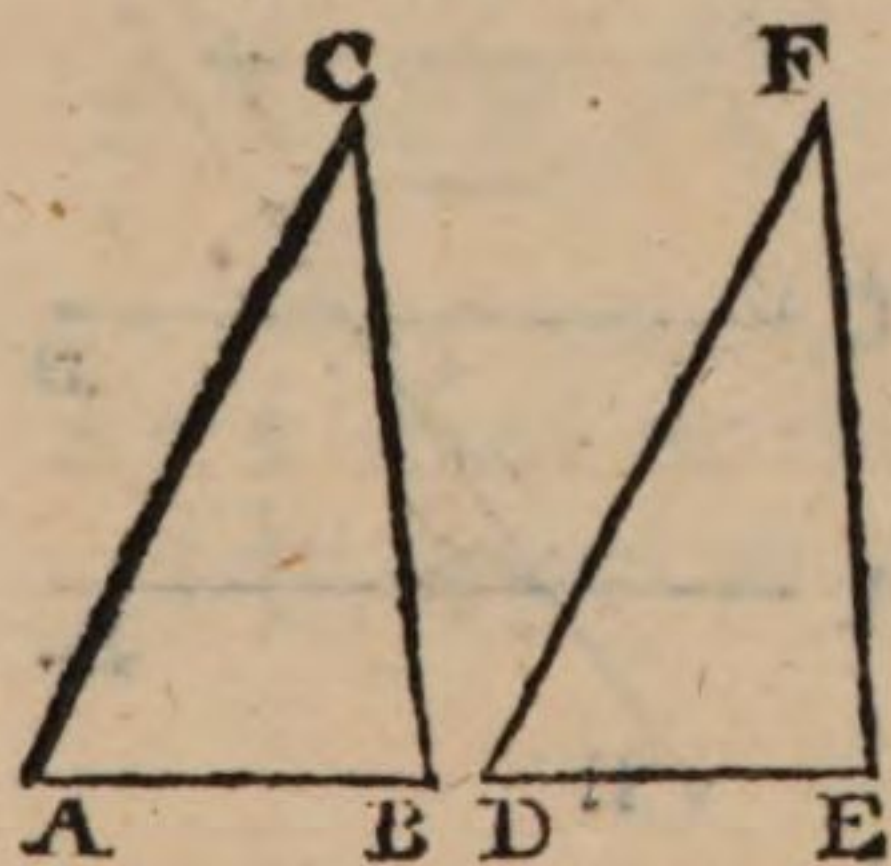
Now as $DE = AB$ (by supposition); therefore the point E falls on B.

But $\angle D = \angle A$ (by sup.); therefore DF will fall on AC.

And since $DF = AC$; therefore the point F falls on C.

Consequently FE will fall on CB.

Therefore the triangles ACB, DFE, are congruous; since every part agrees.



190. THEOREM VI.

If two triangles (ABC, DEF) have two angles (A, B) and the included side (AB) in one, respectively equal to two angles (D, E) and the included side (DE) in the other, each to each; then are those triangles congruous.

DEM. Apply the point D to A, and the line DE to AB.

Now as $DE = AB$ (by sup.); therefore the point E falls on B.

And as $\angle D = \angle A$ (by sup.) therefore the line DF falls on AC.

Now if the line AC is less or greater than the line DF;

Then the line FE not falling on CB, makes the $\angle B$ less or greater than $\angle E$.

But $\angle B = \angle E$ (by sup.); therefore AC is neither less nor greater than DF.

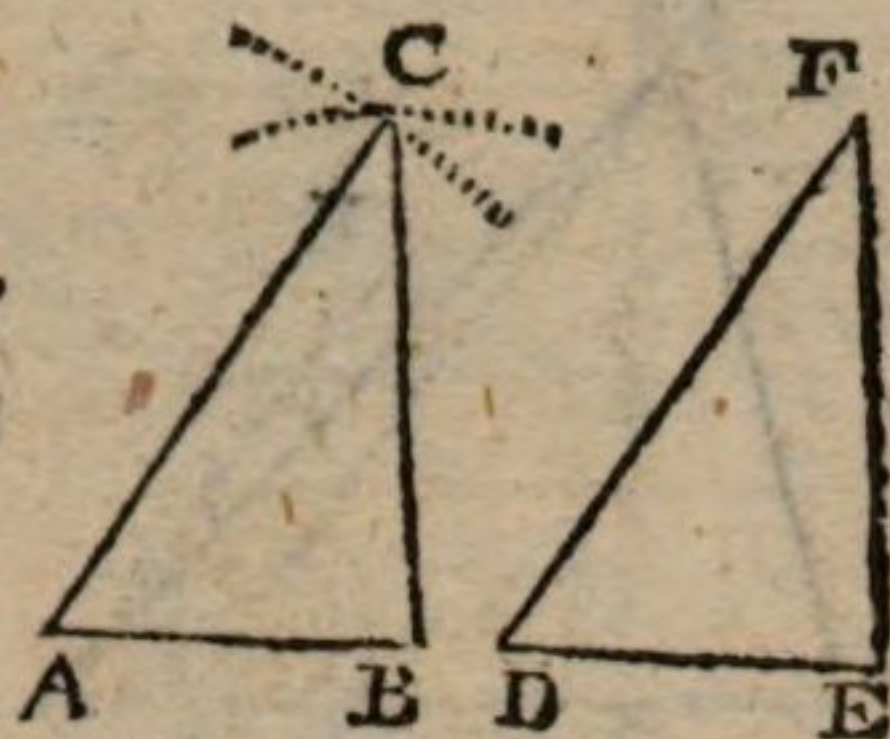
Or the line $AC = DF$; consequently $FE = CB$.

Therefore the triangles are congruous.

191.

191. THEOREM VII.

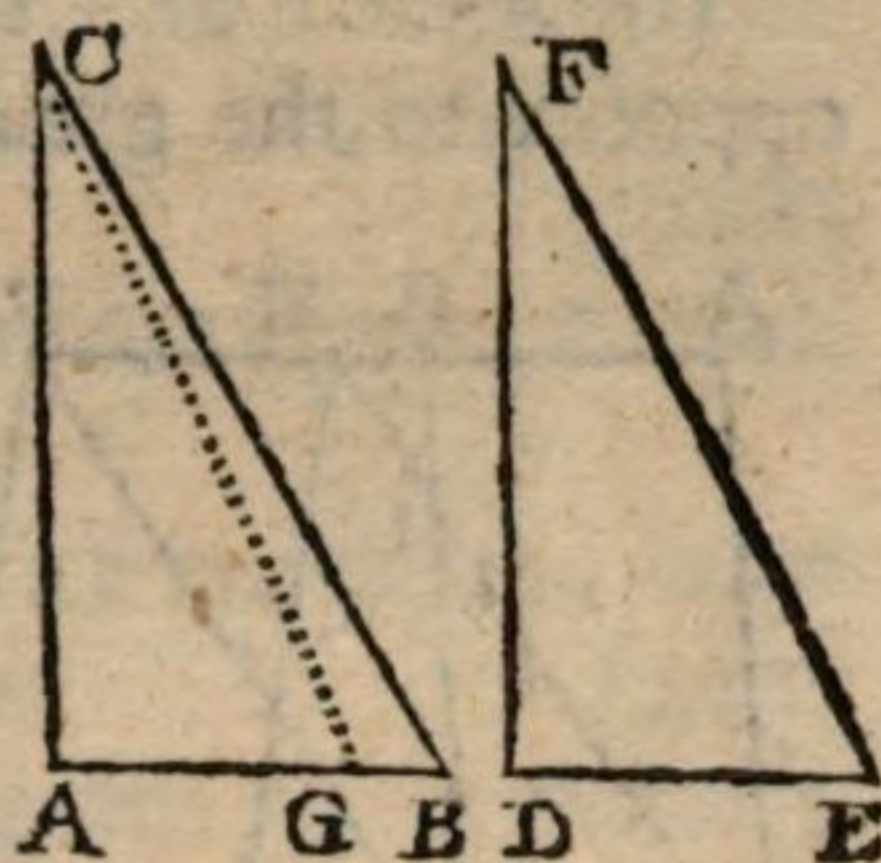
Two triangles (ABC, DEF) are congruous, when the three sides in the one, are equal to the three sides in the other, each to each.



DEM. Apply the point D to A, and the line DE to AB.
 Now as $DE = AB$ (by sup.); therefore the point E falls on B.
 On A, with the radius AC describe an arc.
 Then as $DF = AC$, the point F will fall in that arc.
 Also on B with the radius BC describe another arc, cutting the former.
 And since $EF = BC$, the point F will fall in this arc.
 But the point F can be only where these arcs intersect, as in c.
 Consequently the triangles are congruous.

192. THEOREM VIII.

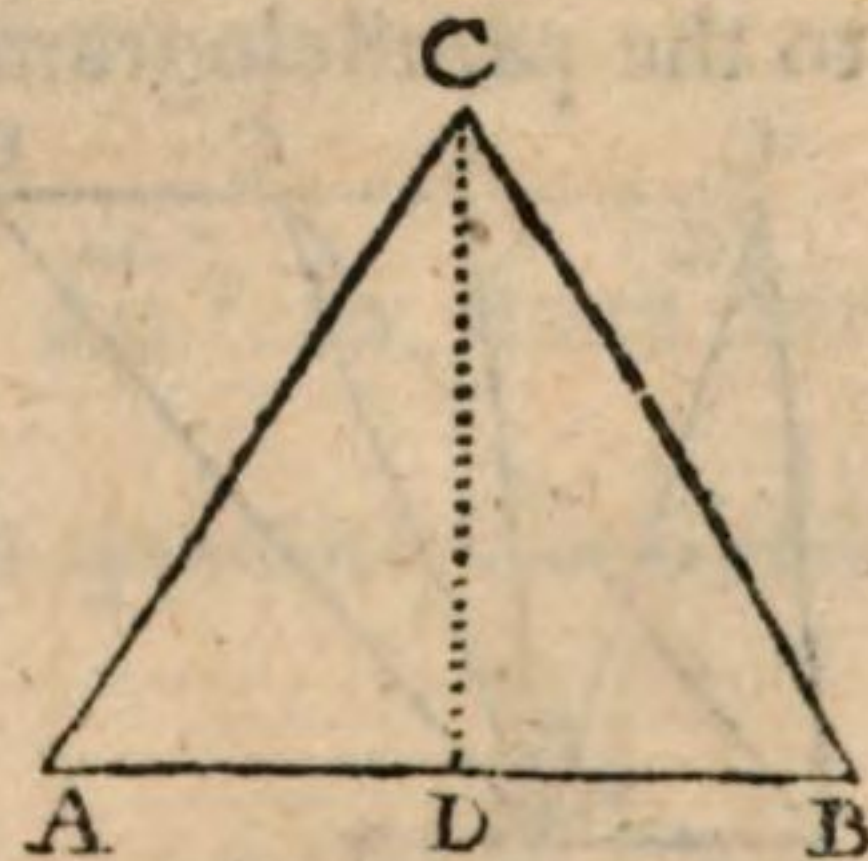
Two triangles (ABC, DEF) are congruous, when two angles (A, B) and a side (AC) opposite to one of them, in one triangle; are respectively equal to two angles (D, E) and a side (DF) opposite to a like angle in the other triangle, each to each.



DEM. Apply the point D to A, and the line DF to AC.
 Now as $DF = AC$ (by sup.), therefore the point F falls on c.
 And as $\angle D = \angle A$ (by sup.), the line DE will fall on the line AB.
 And if the point E does not fall on B, suppose it falls on any other point G, and draw CG.
 Then the angle AGC is equal to the angle DEF. (189)
 And the $\angle ABC = (\angle DEF =) \angle AGC$, which is not true. (186)
 Therefore the point E can fall no where but on the point B.
 Consequently the triangles are congruous.

193. THEOREM IX.

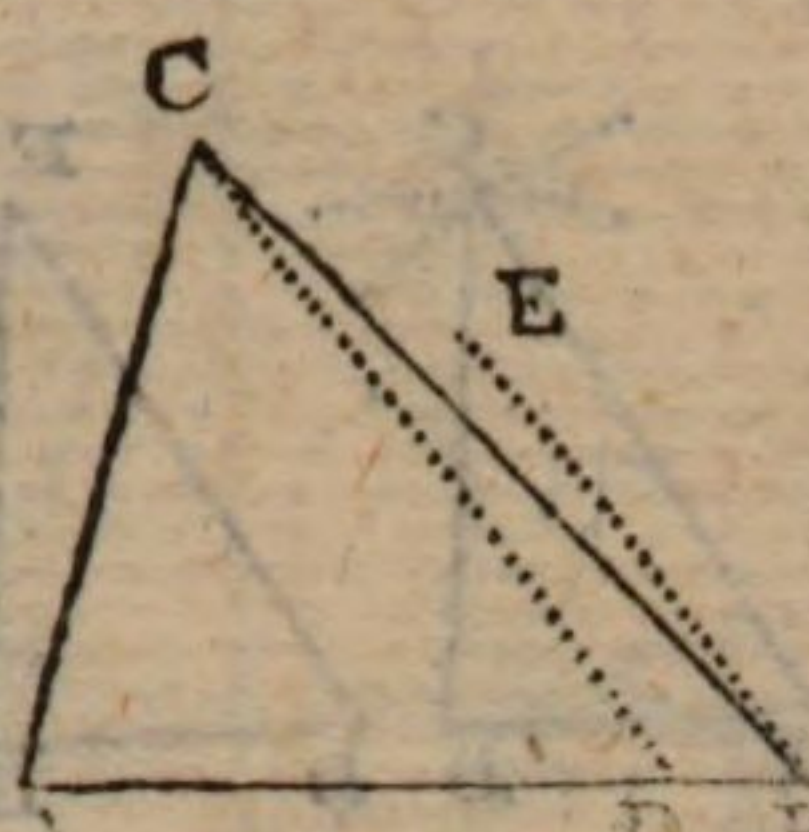
In an Isosceles, or Equilateral triangle (ABC); a line drawn from the vertex (C) to the middle of the base (AB), is perpendicular to the base, and bisects the vertical angle: and the contrary.



DEM. The triangles ADC, BDE, are congruous,
 Since $CA = CB$ (114); $CD = CD$, and $AD = DB$ by supposition:
 Therefore $\angle A = \angle B$, $\angle ACD = \angle BCD$, $\angle ADC = \angle BDC$. (191)
 Consequently CD is at right angles to AB. (108)

194. COROL. Hence in any right lined triangle, where there are equal sides, or angles;

The angles (A, B,) opposite to equal sides (BC, AC,) are equal.
 And the sides (BC, AC,) opposite to equal angles (A, B,) are equal.



195.

THEOREM X.

In every right lined triangle (ABC), the greatest angle (C) is opposite to the greatest side (AB).

DEM. In the greatest side AB, take $AD = AC$, draw CD, and thro' B draw BE parallel to CD.

Then the angles ADC, ACD, are equal. (194)

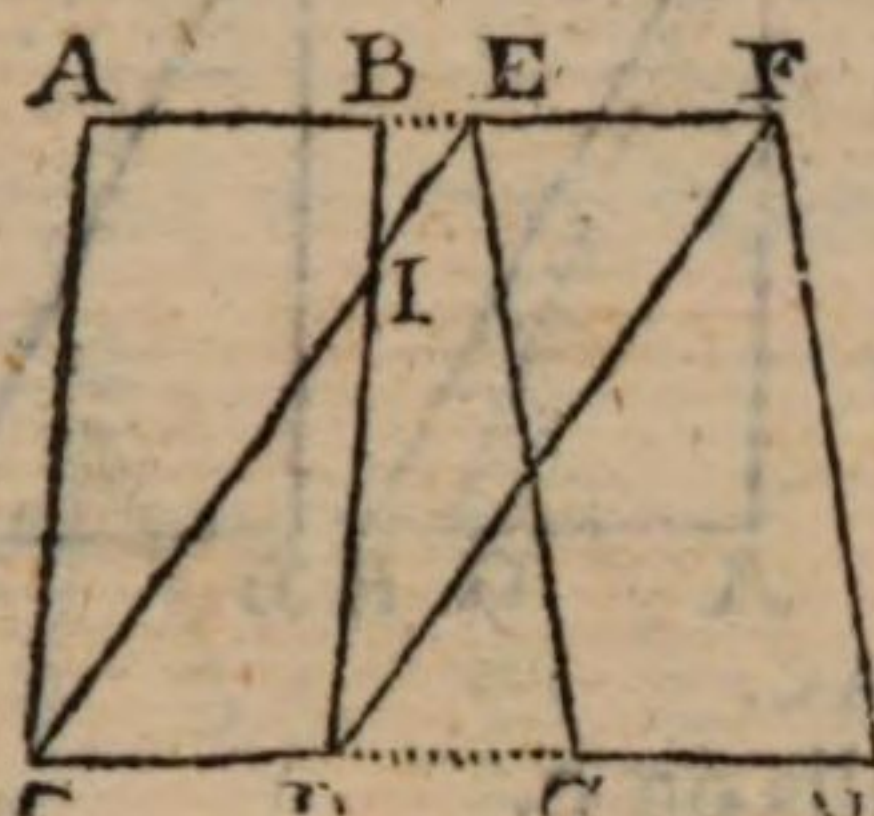
And $\angle ADC = \angle ABE$. (185)

Therefore $\angle ACD = \angle ABE$. (137)

That is, a part of the angle ACB is greater than the angle ABC.

Consequently the $\angle C$ is greater than the $\angle B$; and in the same manner, it will be found to be greater than the $\angle A$.

196. COROL. Hence in every right lined triangle, the greatest side is opposite to the greatest angle.



197.

THEOREM XI.

Parallelograms (AD, DE, EH) standing on the same base (CD), or on equal bases (CD, GH), and between the same parallels, (CH, AF), are equal.

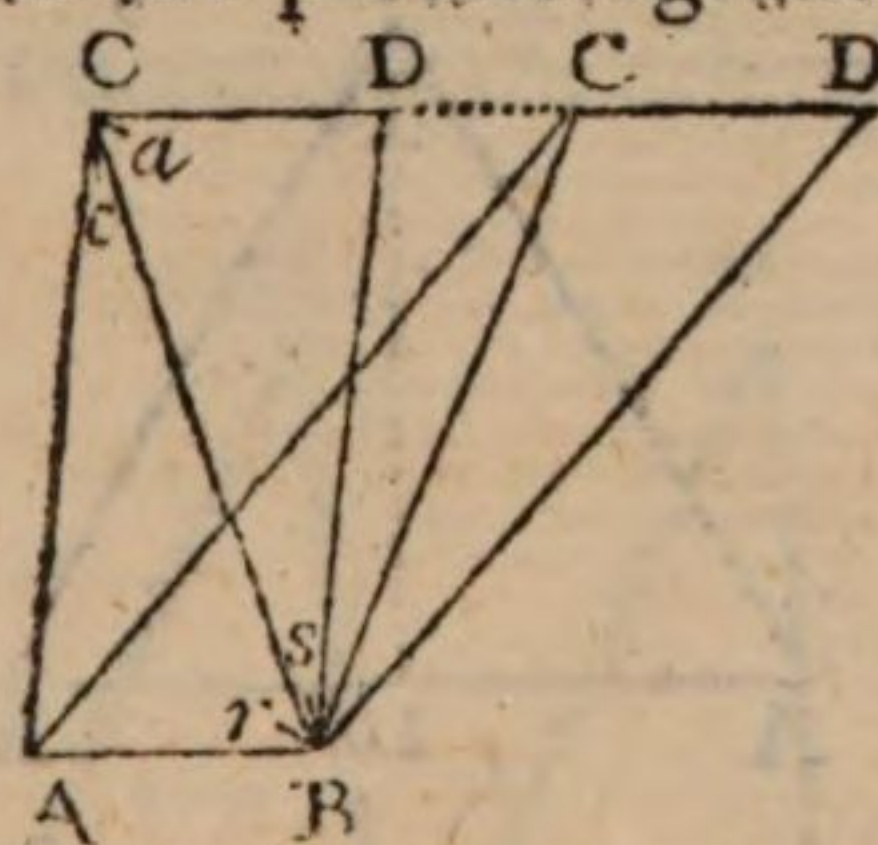
DEM. The triangles ACE, BDF, are congruous. (191)

For $AC = BD$, $CE = DF$ (119); and $AE = (AB + BE =) BF (= EF + BE)$.

Now if from each of the triangles ACE and BDF, be taken the triangle BIE, the remaining trapeziums ABIC and FEID are equal. (139)

Then if to each of the trapeziums ABIC, FEID, be added the triangle CID, their sum will be the parallelograms AD and DE, which are equal. (138)

And in like manner it may be shewn, that the parallelogram EH is equal to the parallelogram ED = AD.



198.

THEOREM XII.

A triangle (ABC) is the half of a parallelogram (AD), when they stand on the same base (AB), and are between the same parallels (AB, CD).

DEM. Since CB is a diagonal to the parallelogram AD, and cuts the parallels AB, CD, and CA, DB.

Then $\angle a = \angle r$, and $\angle c = \angle s$. (185)

And $\angle r$, CB, $\angle c$, are respectively equal to $\angle a$, CB, $\angle s$.

Therefore the triangles ABC and BCD are congruous. (190)

Consequently the triangle ABC is half the parallelogram AD.

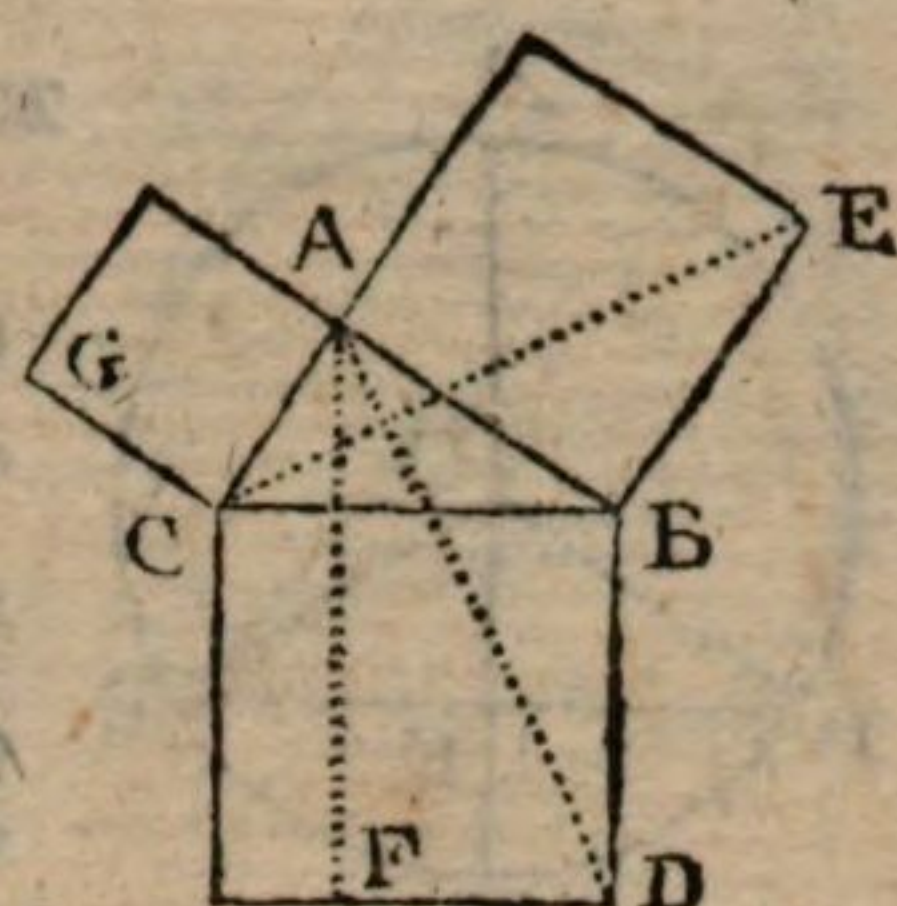
199. COROL. I. Hence every parallelogram is bisected by its diagonal.

200. II. Also, triangles standing on the same base, or on equal bases, and between the same parallels are equal.

They being the halves of equal parallelograms under like circumstances.

201. THEOREM XIII.

In every right angled triangle (BAC), the square on the side (BC) opposite to the right angle (A), is equal to the sum of the squares of the two sides (AB, AC) containing the right angle.



DEM. On the sides AB, AC, BC, construct the squares AG, AE, CD (159); draw AD, CE; and draw AF parallel to BD. (154)

Then the triangles ABD, EBC, are congruous. (189)

For the $\angle ABE = \angle CBD$, being right angles. (121)

To each add the angle ABC, and $\angle EBC$ and $\angle ABD$ are equal. (138)

Therefore EB, BC, $\angle EBC$, are respectively equal to AB, BD, $\angle ABD$.

Also the triangle EBC is half the parallelogram AE. (198)

For they stand upon the same base EB, and are between the same parallels EB and AC, BA making right angles with BE and CA continued.

Likewise the triangle ABD is half the parallelogram BF. (198)

For they stand upon the same base BD, and are between the same parallels BD, AF.

Therefore, as the halves of the parallelograms EA and BF are equal, consequently the parallelogram BF is equal to the square AE. (140)

In the same manner may it be shewn, that the parallelogram CF is equal to the square AG.

But the parallelograms BF and CF together, make the square CD.

Therefore the square CD is equal to the squares EA and AG.

202. COROL. I. Hence if any two sides of a right angled triangle are known, the other side is also known.

For $BC = \text{square root of the sum of the squares of AC and AB.}$

$AC = \text{square root of the difference of the squares of BC and AB.}$

$AB = \text{square root of the difference of the squares of BC and AC.}$

203. Or thus, making the quantities $\overline{BC}^2$, $\overline{AB}^2$, $\overline{AC}^2$, to stand for the squares made on those lines.

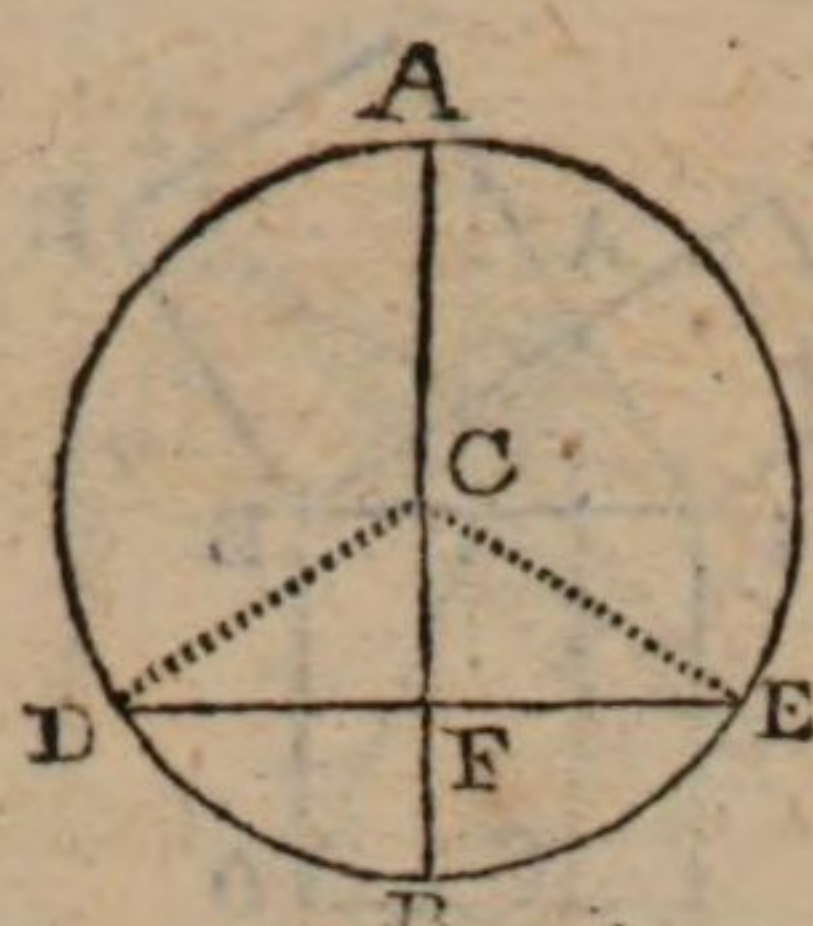
And the mark $\sqrt{}$ to stand for the square root of such quantities as stand under a line joined to the top of this mark.

$$\text{Then } BC = \sqrt{\overline{AC}^2 + \overline{AB}^2}; \quad AC = \sqrt{\overline{BC}^2 - \overline{AB}^2}; \quad AB = \sqrt{\overline{BC}^2 - \overline{AC}^2}.$$

204. COROL. II. Of all the lines drawn from a given point to a given line, the perpendicular is the shortest.

205. COROL. III. The shortest distance between two parallel right lines, is a right line drawn from one to the other perpendicular to both.

206. COROL. IV. Parallel right lines are equidistant; and the contrary. For two opposite sides of a rectangular parallelogram are equal (119); and each is the shortest distance between the other sides.



207. THEOREM XIV.

In any circle, a diameter (AB) drawn perpendicular to a chord (DE), bisects that chord and its subtended arc (DBE).

DEM. From the centre c , draw the radii CD , CE , to the extremities of the chord DE .

Then the triangle CDE , CFD , are congruous. (192)

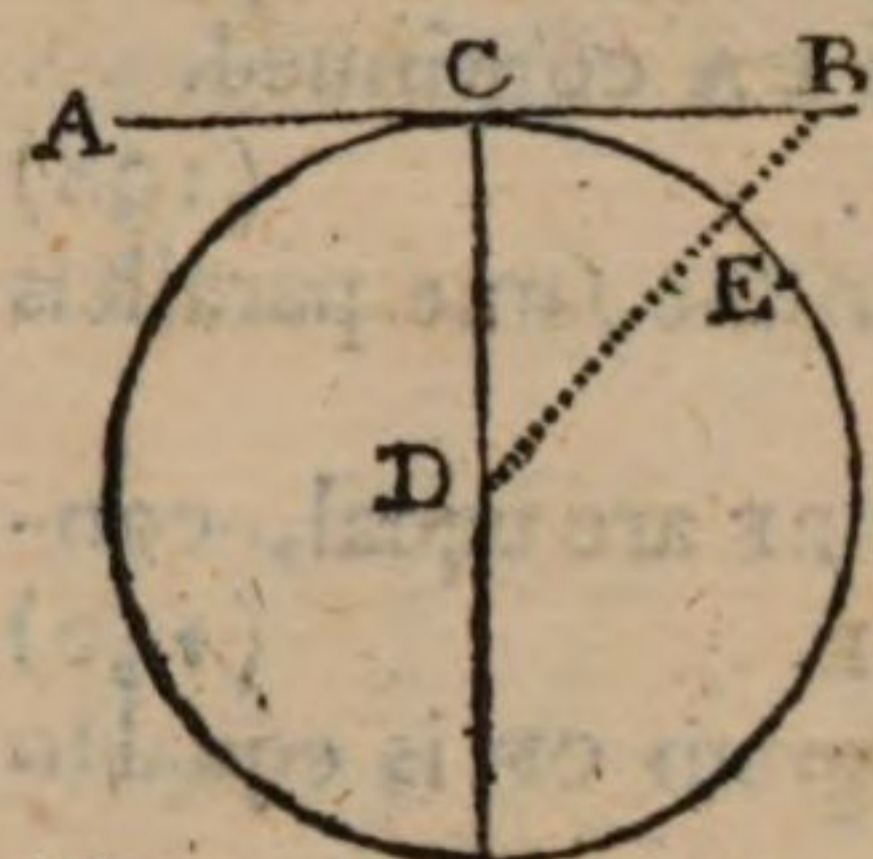
For CF being at right angles to DE , the $\angle CFD = \angle CFE$. (108)

And the triangle CDE being Isosceles (114), the $\angle D = \angle E$ (194). Also CF is common.

Therefore $DF = FE$: And the arc $DB = BE$.

For those arcs measure the equal angles FCE , FCD . (143)

208. COROL. Hence, in a circle, a right line drawn thro' the middle of a chord at right angles to it, passes thro' the centre of that circle; and the contrary.



209. THEOREM XV.

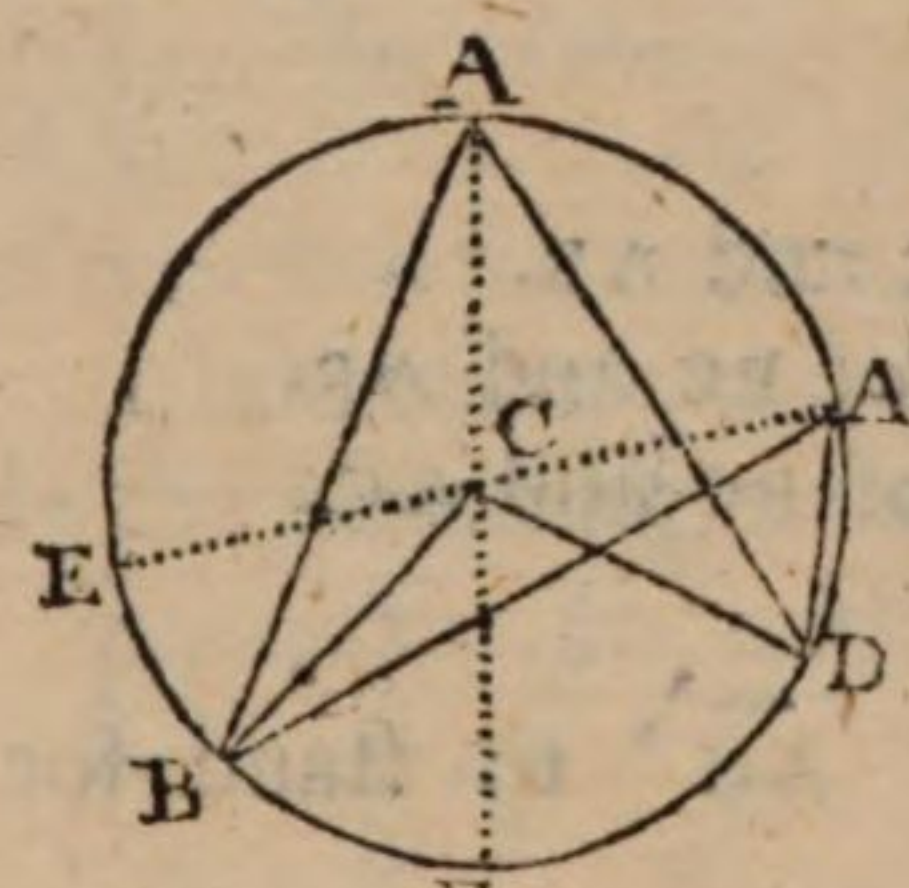
A tangent (AB) to a circle, is perpendicular to a diameter (DC) drawn to the point of contact (C).

DEM. If it be denied that DC is perpendicular to AB . Then from the centre D , let some other line DB , cutting the circle in E , be drawn perpendicular to AB .

Now the angle DBC being right, the angle DCB is acute. (187)

And $DC = DE$, is greater than DB (196), which is absurd.

Therefore no other line passing thro' the centre can be perpendicular to the tangent, but that which meets it at the point of contact.



210. THEOREM XVI.

An angle (BCD) at the centre of a circle, is double to the angle (BAD) at the circumference, when those angles stand on the same arc BD).

DEM. Thro' the point A draw the diameter AE .

Then the angle $ECD = \angle CAD + \angle CDA$. (186)

But the $\angle CAD = \angle CDA$. (194)

Therefore the $\angle ECD$ is equal to twice the angle CAD .

In the same manner it may be shewn, that the angle BCE is equal to twice the angle BAE .

Consequently the angle $BCD (= \angle BCE + \angle ECD)$ is equal to twice the angle $BAD (= \angle BAE + \angle EAD)$. (138)

211. COROL. I. Hence an angle (BAD) at the circumference is measured by half the arc (BD) on which it stands.

For the angle at the centre (BCD) is measured by the arc BD . (106)

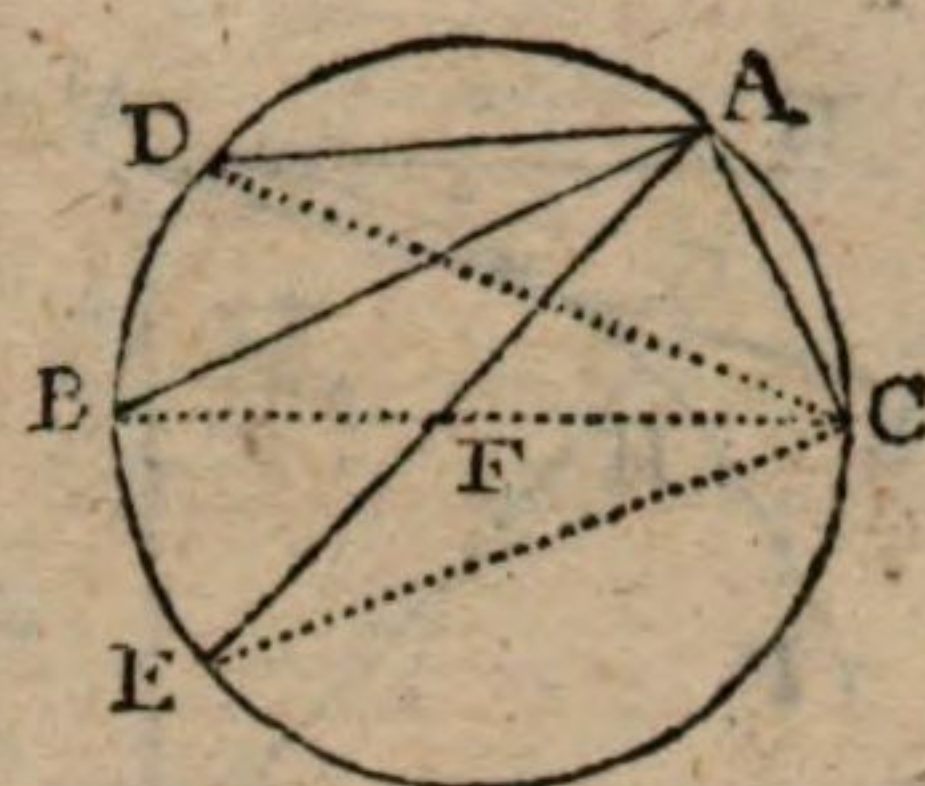
Consequently the angle $BAD =$ half the angle BCD , is measured by half the arc BD .

212. II. All angles in the circumference and standing on the same arc are equal.

213.

THEOREM XVII.

*An angle (BAC) in a semicircle, is a right one.
An angle (DAC) in a segment less than a semicircle, is obtuse.
An angle (EAC) in a segment greater than a semicircle, is acute.*



DEM. For the angle BAC is measured by half the semicircular arc BEC, which is equal to 180° . (211)

And $\angle DAC$ is measured by half the arc DEC, greater than 180° .

Also $\angle EAC$ is measured by half the arc EC, less than 180° .

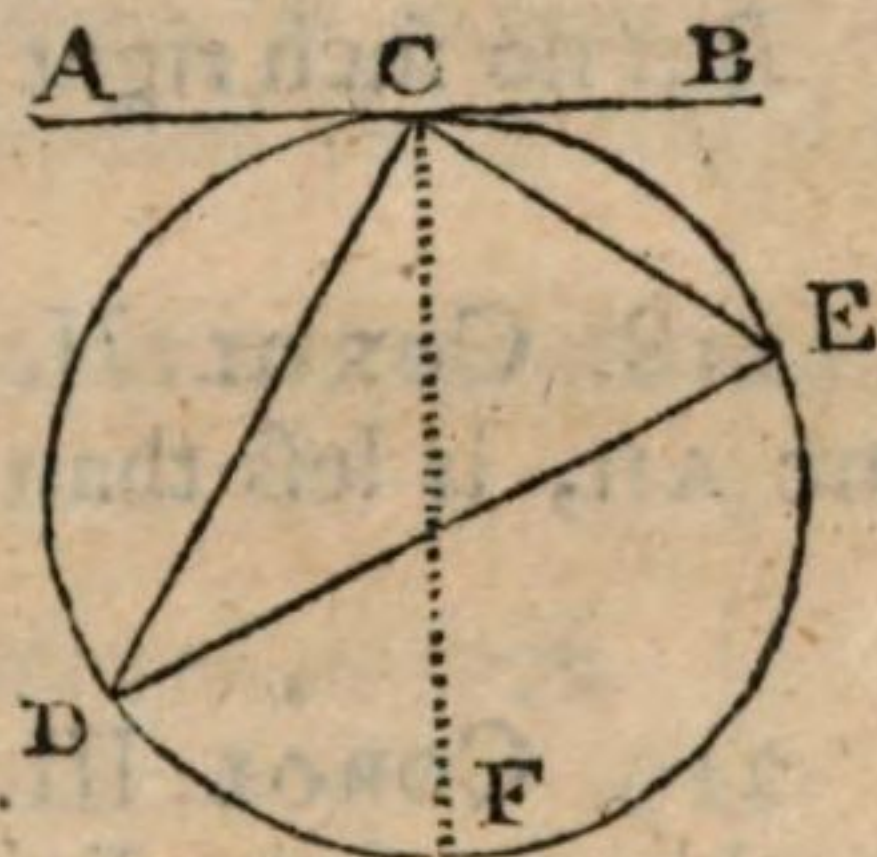
Therefore these angles are respectively equal to, greater, or less than 90° degrees.

214. COROL. Hence in a right angled triangle (BAC); the angular point (A) of the right angle, and the ends (B, C) of the opposite side, are equally distant from (F) the middle of that side; that is, a circle will always pass thro' the right angle and the ends of its opposite side taken as a diameter.

215.

THEOREM XVIII.

The angle (ACD) formed by a tangent (AB) to a circle (CDE), and a chord (CD) drawn from the point of contact (C), is equal to an angle (CED) in the alternate segment.



DEM. Draw the diameter CF; then $\angle ACF$ is right. (209)

Therefore the $\angle ACF$ is measured by half the arc CDF. (107)

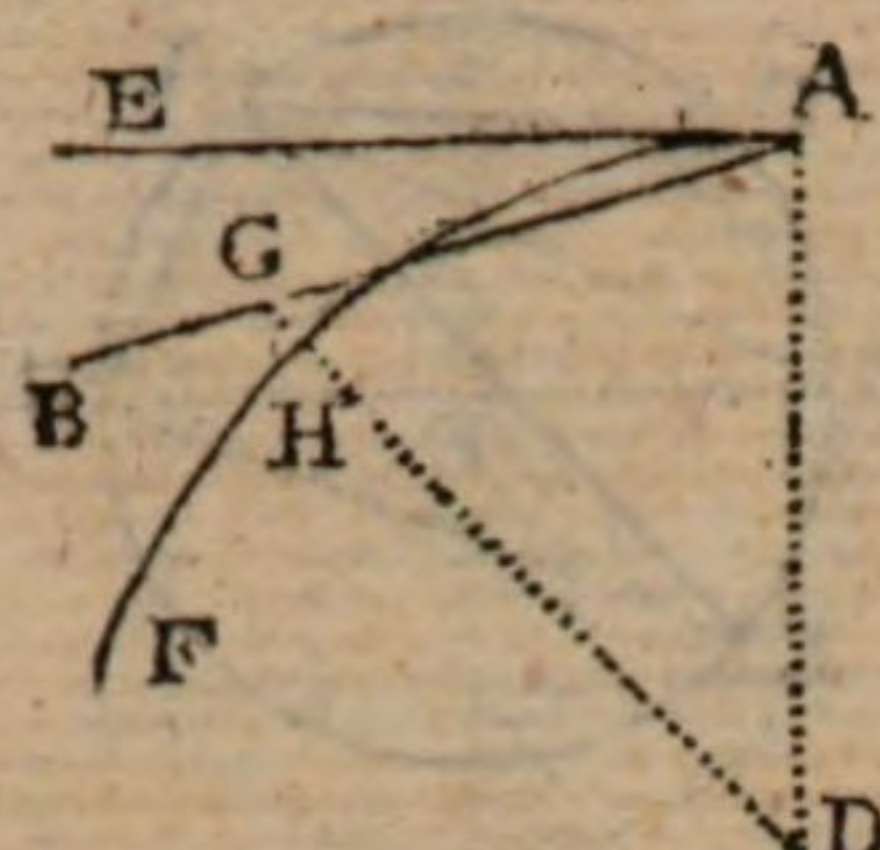
But the angle DCF is measured by half the arc DF. (211)

Therefore $\angle ACD (= \angle ACF - \angle DCF)$ is measured by half the arc DC $(= CDF - DF)$.

And $\angle CED$ is measured by half the arc CD. (211)

Therefore $\angle ACD = \angle CED$. (141)

* A small $^\circ$ put above any figure, signifies degrees.



216. THEOREM XIX.

Between a circular arc (AHF) and its tangent (AE), no right line can be drawn from the point of contact (A).

DEMON. For if any other right line can be drawn, let it be the right line AB.

From D the centre of AHF, draw DG perpendicular to AB, cutting AB in G, and the arc in H.

Now as $\angle DGA$ is right; therefore DA is greater than DG. (196)

But $DA = DH$ (100). Therefore DH is greater than DG, which is absurd.

Consequently no right line can be drawn between the tangent AE and the arc AHF.

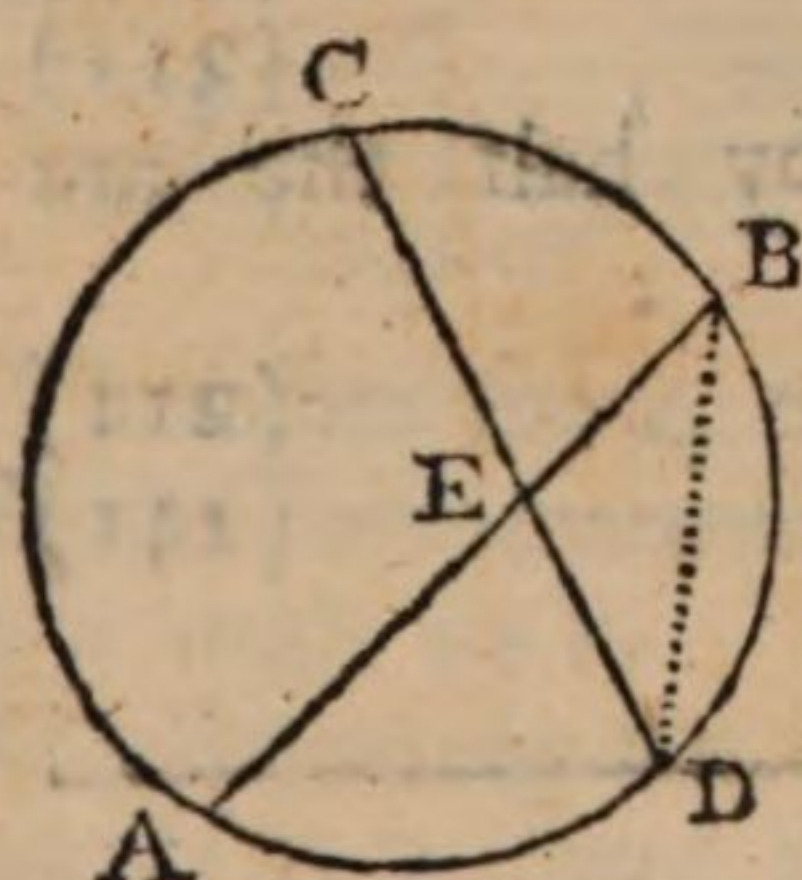
217. COROL. I. Hence the angle DAH, contained between the radius DA, and an arc AH, is greater than any right lined acute angle.

For a right line AB must be drawn from A, between the tangent AE and radius AD, to make an acute angle.

But no such right line can be drawn between AE and the arc AH.

218. COROL. II. Hence the angle EAH, between the tangent EA and arc AH, is less than any right lined acute angle.

219. COROL. III. Hence it follows, that at the point of contact, the arc has the same direction as the tangent, and is at right angles to the radius drawn to that point.



220. THEOREM XX.

If two right lines (AB, CD) intersect any how (in E) within a circle; their inclination (AED, or CEB) is measured by half the sum of the intercepted arcs (AD, CB).

DEM. For drawing DB;

The $\angle AED = \angle EDB + \angle EBD$. (186)

But the $\angle EDB$ is measured by $\frac{1}{2}$ arc CB, (211)

And the $\angle EBD$ is measured by $\frac{1}{2}$ arc AD. (211)

Consequently the $\angle AED$ is measured by half the arc CB together with half the arc AD.

SECTION IV.

OF PROPORTION.

Definitions and Principles.

221. One quantity A, is said to be measured or divided by another quantity B, when A contains B some number of times.

Thus, if $A = 20$, and $B = 5$; then A contains B four times. A is called a multiple of B; and B is said to be a part of A.

222. If a quantity A ($= 20$) contains another B ($= 5$) as many times as a quantity C ($= 24$) contains another D ($= 6$); then A and C, are called like multiples of B and D. B and D, are called like parts of A and C: And A is said to have the same relation to B, as C has to D.

Or, like multiples of quantities are produced, by taking their Rectangle, or Product, by the same quantity, or by equal quantities.

The Rectangle or Product of quantities (A & B) is expressed by writing this mark $\times$ between them. Thus $A \times B$, or $B \times A$.

223. When two quantities of a like kind are compared together, the relation which one of them has to the other in respect to quantity, is called Ratio.

The first term of a ratio, or the quantity compared, is called the antecedent; and the second term, or the quantity compared to, is called the Consequent.

A ratio is usually denoted by setting the antecedent above the consequent with a line drawn between them.

Thus $\frac{A}{B}$ signifies, and is thus to be read, the ratio of A to B.

The multiple of a ratio $\frac{A}{B}$, is the product of each of its terms by the same

quantity, or by equal quantities. Thus $\frac{A \times C}{B \times C}$ is the ratio $\frac{A}{B}$ taken c times.

The product of two, or more ratios, $\frac{A}{B}, \frac{C}{D}$ is expressed by taking the product of the antecedents for a new antecedent, and the product of the consequents for a new consequent. Thus $\frac{A \times C}{B \times D} = \frac{A}{B} \times \frac{C}{D}$.

224. Equal ratios are those where the antecedents are like multiples or parts of their respective consequents.

Thus in the quantities A, B, C, D: Or 20, 5, 24, 6.

In the ratio of A to B, or of 20 to 5, the antecedent is a multiple of its consequent four times.

And in the ratio of C to D, or of 24 to 6, the antecedent is a multiple of its consequent four times.

That is the ratio of A to B is the same as the ratio of C to D.

And this equality of ratios is thus expressed $\frac{A}{B} = \frac{C}{D}$.

225. Ratio of equality is, when the antecedent is equal to the consequent.

226. Four quantities are said to be proportional, which when compared together by two and two, are found to have equal ratios.

Thus, let the quantities to be compared be A, B, C, D : Or 20, 5, 24, 6.
Now in the ratio of A to B, or of 20 to 5 ; A contains B four times.
And in the ratio of C to D, or of 24 to 6 ; C contains D four times.

Then the ratios of A to B, and of C to D, are equal : Or $\frac{A}{B} = \frac{C}{D}$. (224)

And their proportionality is thus expressed $A : B :: C : D$. (166)

Also, in the ratio of A to C, or of 20 to 24 ; C contains A, once and $\frac{1}{6}$.

And in the ratio of B to D, or of 5 to 6 ; D contains B, once and $\frac{1}{6}$.

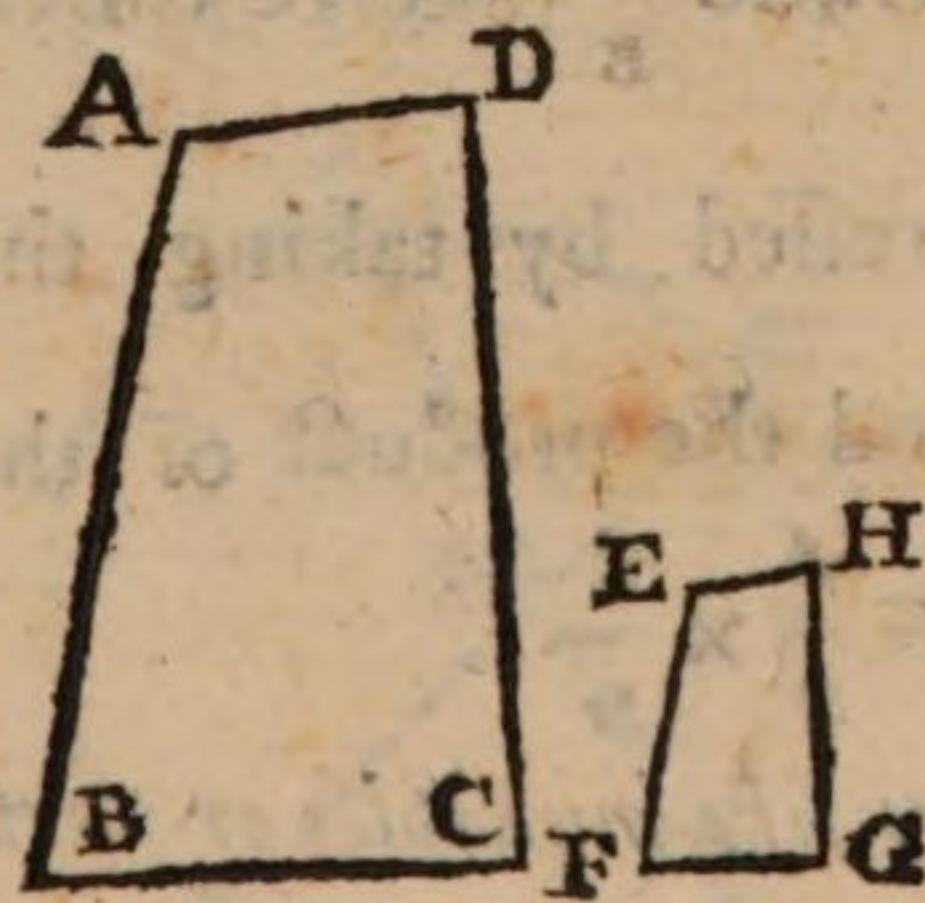
Where the ratios are likewise equal, viz. $\frac{A}{C} = \frac{B}{D}$.

And these are also proportional $A : C :: B : D$.

227. So that when four quantities of the same kind are proportional, the ratio between the first and second, is equal to the ratio between the third and fourth ; and this proportionality is called Direct.

228. Also the ratio between the first and third, is equal to the ratio between the second and fourth ; and this proportionality is called Alternate.

229. Similar, or like, right lined figures, are such which are equiangular, (that is, whose several angles are equal one to the other) ; and also, the sides about the equal angles proportional.



Thus if the figures AC and EG are equiangular,
And $AB : BC :: EF : FG$; Or $BC : CD :: FG : GH$.
Then are those figures called similar or like figures.
And the like in Triangles, or other figures.

230. Like arcs, chords, or tangents, in different circles, are those which subtend, or are opposite to, equal angles at the centre.

231.

THEOREM XIX.

Quantities and their like multiples, have the same ratio.

That is, the ratio of A to B, is equal to the ratio of twice A to twice B, of thrice A to thrice B, &c. Or thus $\frac{A}{B} = \frac{2A}{2B} = \frac{3A}{3B} \&c. = \frac{C \times A}{C \times B}$.

DEM. For the ratio of A to B, must either be equal to the ratio of like multiples of A and B, or to the ratio of unlike multiples of them.

Now suppose the ratio of A to B is equal to the ratio of their unlike multiples, $C \times A$, $D \times B$; that is $\frac{A}{B} = \frac{C \times A}{D \times B}$.

Then $A : B :: C \times A : D \times B$ (227). And $A : C \times A :: B : D \times B$ (228).

Therefore $\frac{A}{C \times A} = \frac{B}{D \times B}$ (226). Where the consequents are unequal multiples of their antecedents, by supposition.

But $\frac{A}{C \times A}$ is not equal to $\frac{B}{D \times B}$. (224)

Then $A : C \times A :: B : D \times B$ is not true.

Also $A : B :: C \times A : D \times B$ is not true.

Consequently $\frac{A}{B}$ is unequal to $\frac{C \times A}{D \times B}$.

Therefore the ratio of unlike multiples of two quantities, is not equal to the ratio of those quantities.

Consequently the ratio of two quantities, and the ratio of their like multiples are the same. Or $\frac{A}{B} = \frac{C \times A}{C \times B}$.

232. COROL. I. In any ratio, if both terms contain the same quantity or quantities; the value of the ratio will not be altered by omitting, or taking away, those quantities. For $\frac{C \times A}{C \times B} = \frac{A}{B}$, by taking away C.

233. II. Quantities, and their like parts have equal ratios. For A and B are like parts of $C \times A$ and $C \times B$.

234. III. Quantities, and their like multiples, or like parts are proportional. For $A : B :: C \times A : C \times B$. And $C \times A : C \times B :: A : B$.

235. IV. If quantities are equal, their like multiples, or like parts are also equal. For if $A = B$; and $\frac{A}{B} = \frac{C \times A}{C \times B}$.

Then are the antecedents and consequents in a ratio of equality. (224)

236. V. If the parts of one quantity, are proportional to the parts of another quantity, they are like parts of their respective quantities. For only like parts are proportional to their wholes. (234)

237. VI. Ratios, which are equal to the same ratio, are equal to one another. For the ratio of $\frac{A}{B} = \frac{C \times A}{C \times B} = \frac{D \times A}{D \times B} \&c.$ (231)

238. VII. Proportions, which are the same to the same proportion, are the same to one another.

If $A : B :: C : D$; and $A : B :: E : F$; Then $C : D :: E : F$.

For $\frac{A}{B} = \frac{D}{C}$; and $\frac{A}{B} = \frac{E}{F}$ (226). Then $\frac{C}{D} = \frac{E}{F}$. (137)

239. VIII. If two ratios or products are equal, their like multiples, either by the same or by equal quantities, or by equal ratios, are also equal.

That is, If $\frac{A}{B} = \frac{C}{D}$: Then $\frac{A \times E}{B \times E} = \frac{C \times E}{D \times E}$.

And if $E = F$: Then $\frac{A \times E}{B \times E} = \frac{C \times F}{D \times F}$.

And if $\frac{E}{F} = \frac{G}{H}$: Then $\frac{A \times E}{B \times F} = \frac{C \times G}{D \times H}$.

For in either case, the ratios may be considered as quantities.

240.

THEOREM XX.

Equal quantities (A and B) have the same ratio or proportion to another quantity (C). And any quantity has the same ratio to equal quantities.

That is, If $A = B$: Then $A : C :: B : C$. And $C : A :: C : B$.

DEM. Since $A = B$; then C is the like multiple or part of B, as it is of A. And $A : B :: C : C$ (234). Therefore $A : C :: B : C$ (228).

Also $C : C :: A : B$ (234). Therefore $C : A :: C : B$ (228).

241. COROL. I. Hence, When the antecedents are equal, the consequents are equal; and the contrary.

242. II. Quantities are equal, which have the same ratio to another quantity; or to like multiples or parts of another quantity.

Thus, if $A : C :: B : C$. Then $A = B$.

243. III. Since $A : C :: B : C$ and $C : A :: C : B$. Therefore when four quantities are in proportion, As antecedent is to consequent, so is antecedent to consequent: Then shall the first consequent be to its antecedent, as the second consequent to its antecedent: And this is called *the inversion of ratios*.

244.

THEOREM XXI.

In two, or more, sets of proportional quantities, the rectangles under the like terms are proportional.

That is, If $A : B :: C : D$; and $E : F :: G : H$,

Then $A \times E : B \times F :: C \times G : D \times H$.

DEM. Since $\frac{A}{B} = \frac{C}{D}$; And $\frac{E}{F} = \frac{G}{H}$. (227)

Therefore $\frac{A \times E}{B \times F} = \frac{C \times G}{D \times H}$. (239)

Consequently $A \times E : B \times F :: C \times G : D \times H$. (226)

245.

THEOREM XXII.

In four proportional quantities $A : B :: C : D$. Then the Rectangle or Product of the two extremes, is equal to the Rectangle or Product of the two means. That is $A \times D = B \times C$.

DEM. Since $A : B :: C : D$ by supposition. Therefore $\frac{A}{B} = \frac{C}{D}$ (227).

And $\frac{A}{B} = \frac{A \times D}{B \times D}$ (239). Also $\frac{C}{D} = \frac{C \times B}{D \times B}$ (239).

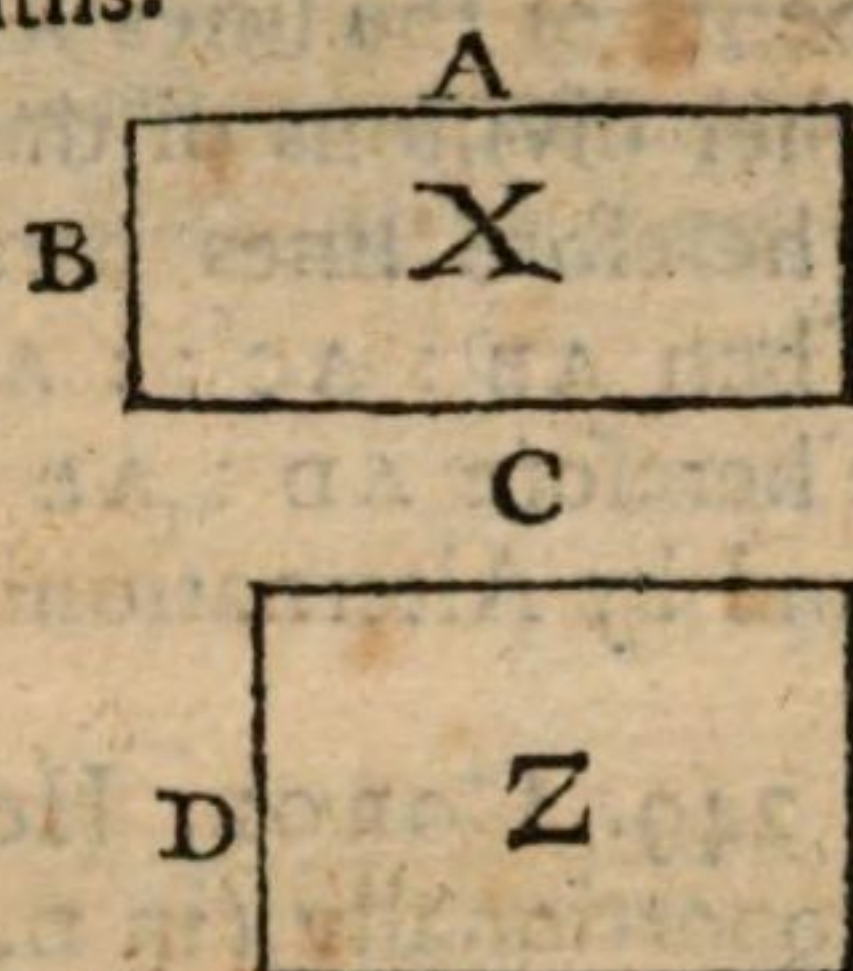
Therefore $\frac{A \times D}{B \times D} = \frac{C \times B}{D \times B}$ (137). Where the consequents are equal.

Consequently $A \times D = C \times B$ (241).

246. Hence, If the Rectangle or product of two quantities, is equal to the Rectangle or product of other two quantities; those four quantities are proportional.

Thus, suppose the two rectangles x , z , are equal.

Where A , C , are their lengths, and B , D , their breadths.



Then $A \times B = C \times D$ by supposition.

Therefore $A : C :: D : B$.

That is, As the length of x is to the length of z .

So the breadth of z is to the breadth of x .

In such cases, the lengths are said to be to one another reciprocally as their breadths.

Or that the proportion $A : C :: D : B$ is reciprocal when $A \times B = C \times D$.

247.

THEOREM XXIV.

If four quantities are proportional; then will either of the extremes, and the ratio of the product of the means to the other extreme, be in a ratio of equality: And either mean, and the ratio of the product of the extremes to the other mean, will be also in a ratio of equality.

That is, If $A : B :: C : D$. Then $A = \frac{B \times C}{D}$. And $B = \frac{A \times D}{C}$.

DEM. Since $A : B :: C : D$ by supposition.

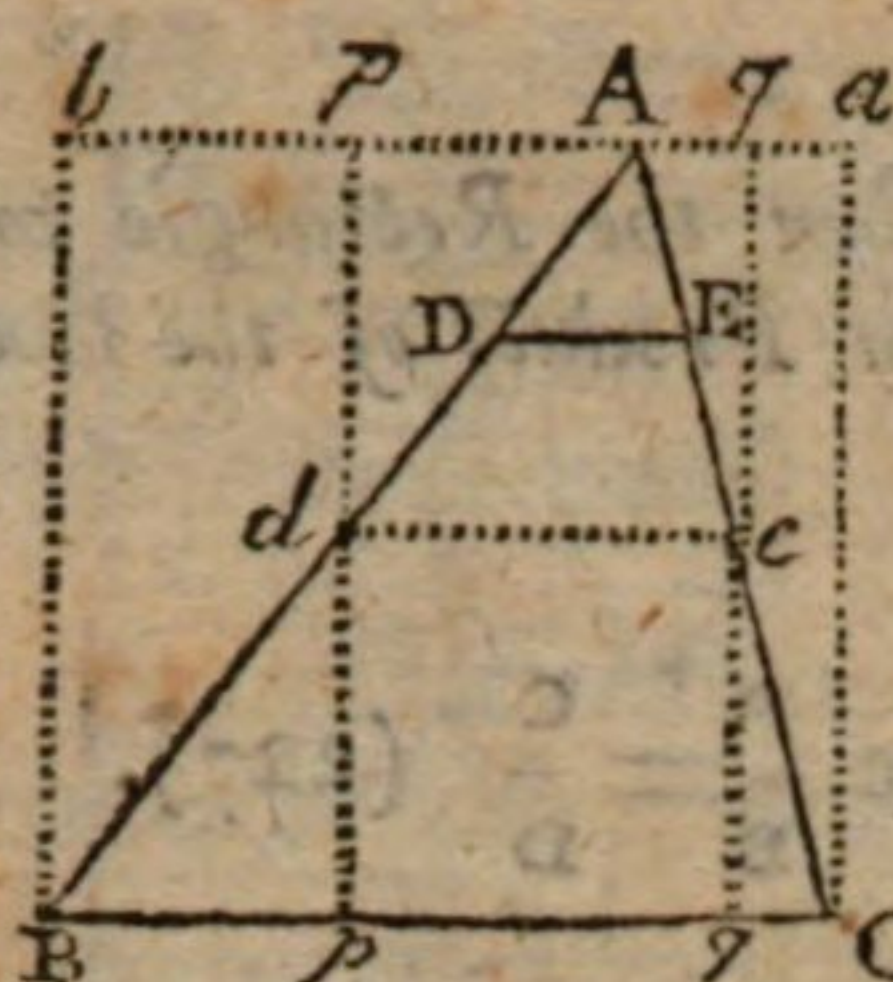
Therefore $A \times D = B \times C$ (245).

And $\frac{A \times D}{C} = \frac{B \times C}{C}$ (240). Also $\frac{B \times C}{D} = \frac{A \times D}{D}$ (240).

But $B = \frac{B \times C}{C}$ (232). And $A = \frac{A \times D}{D}$ (232).

Therefore $\frac{A \times D}{C} = B$ And $\frac{B \times C}{D} = A$ (137).

248.



248. THEOREM. XXV.

In any plane triangle (ABC), any two adjoining sides (AB, AC,) are cut proportionally by a line (DE) drawn parallel to the other side (BC), viz.

$$AD : DB :: AE : EC.$$

DEM. Thro' B and c, draw Bb ca at right angles to BC, meeting ba drawn thro' A parallel to

BC: Thro' p, q, the middles of Ab, Aa, draw pp, qq, parallel to Bb or ca, meeting AB, AC, in the points dc, ; and join dc.

Then since the triangles Adp, Bdp, and Acq, Ccq are congruous. (190)

Therefore Ad = Bd, Ac = Cc, pd = pc, qc = qc.

But pp = qq (206): Therefore pd = qc. (140)

And dc is parallel to BC. (206)

In the same manner it may be shewn, that lines parallel to Bb, drawn thro' the middles of Ap, pb; Aq, qa; will also bisect Ad, Bd; Ac, Cc; and that lines adjoining these points of bisection will also be parallel to BC: And the same may be proved at any other bisections of the segments of the lines Ab, Aa. Also the like may be readily inferred at any other divisions of the lines Ab, Aa.

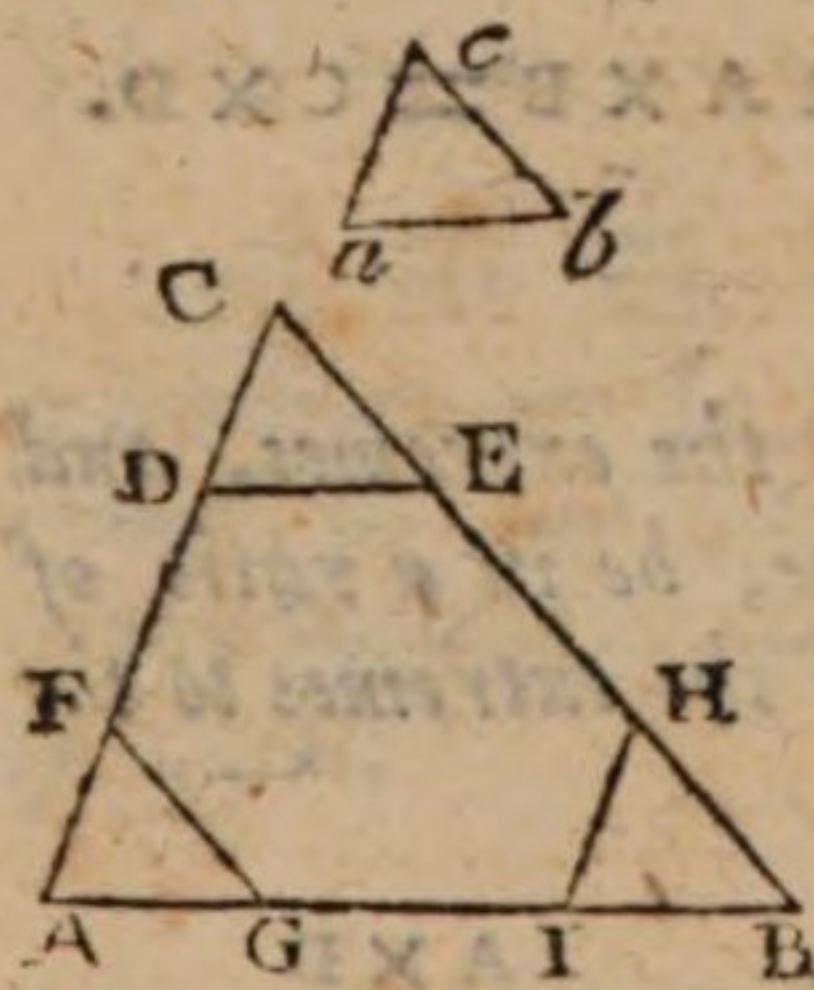
Therefore lines parallel to BC, cut off like parts from the lines AB, AC.

Then AB : AC :: AD : AE. And AB : AC :: BD : CE. (233)

Therefore AD : AE :: BD : CE. (238)

And by Alternation AD : BD :: AE : CE. (228)

249. COROL. Hence, When the sides (AB, AC) of a triangle are cut proportionally (in D, E) the segments (AD, AE; DB, EC) of those sides are proportional to the sides.



250. THEOREM XXVI.

In equiangular triangles (ABC, abc), the sides about the equal angles are proportional; and the sides opposite to equal angles are also proportional.

DEM. In CA, CB, take CD = ca, CE = cb; and draw DE.

Then the triangles CDE, cab, being congruous. (189)

The $\angle CDE = (\angle ca =) \angle A$. Therefore DE is parallel to AB. (185)

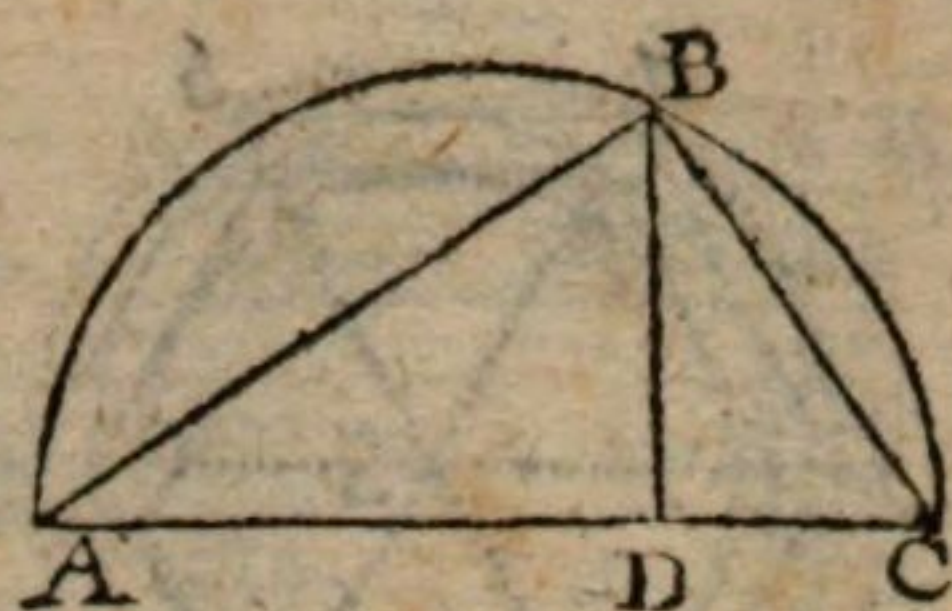
In the same manner, taking AF = ac, AG = ab; also BH = bc, BI = ba; and drawing FG, HI, the triangles AGF, IBH, abc, are congruous; therefore FG is parallel to CB, and HI is parallel to CA.

Then $(CD =) ca : CA :: (CE =) cb : CB.$
 $(AF =) ca : CA :: (AG =) ab : AB.$
 $(BH =) bc : BC :: (BI =) ab : AB.$ } (242)

251. COROL. Hence, Triangles having one angle in each equal, and the sides about those equal angles proportional, those triangles are equiangular and similar.

252. THEOREM XXVII.

In a right angled triangle (ABC), if a line (BD) be drawn from the right angle (B) perpendicular to the opposite side (AC); then will the triangles (ABD, BCD) on each side the perpendicular be similar to the whole (ABC), and to one another.



DEM. For in the triangles ABC, ADB, the $\angle A$ is common,

And the right angle $ABC = \text{right angle } ADB$.

Therefore the remaining $\angle C = \angle ABD$. (188)

In the same manner it will appear, that the triangles ABC, BDC, are like.

Therefore the triangles ABD, BCD, are also similar.

253. COROL. I. Hence, $AC : AB :: AB : AD$.

$AC : BC :: BC : DC$.

$AD : DB :: DB : DC$.

(250)

254. II. Hence a right line (BD) drawn from the circumference of a circle perpendicular to the diameter (AC) is a mean proportional between the segments (AD, DC) of the diameter.

And $AD \times DC = DB^2$.

(245)

For a circle whose diameter is AC, will pass thro' A, B, C.

(214)

255. THEOREM XXVIII.

In a circle, If two chords (AB, CD) intersect each other (in E), either within the circle, or without by prolonging them; then the rectangle under the segments terminated by the circumference and their intersection, will be equal.

That is, $AE \times EB = CE \times ED$.

DEM. Draw the lines BC, DA.

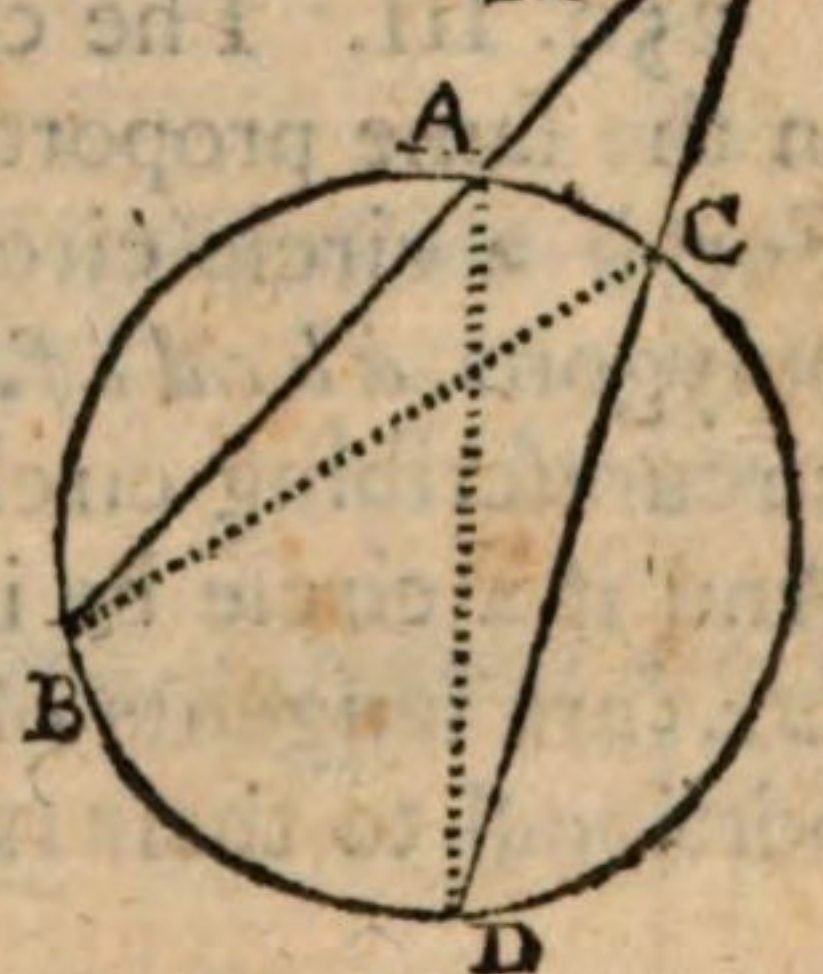
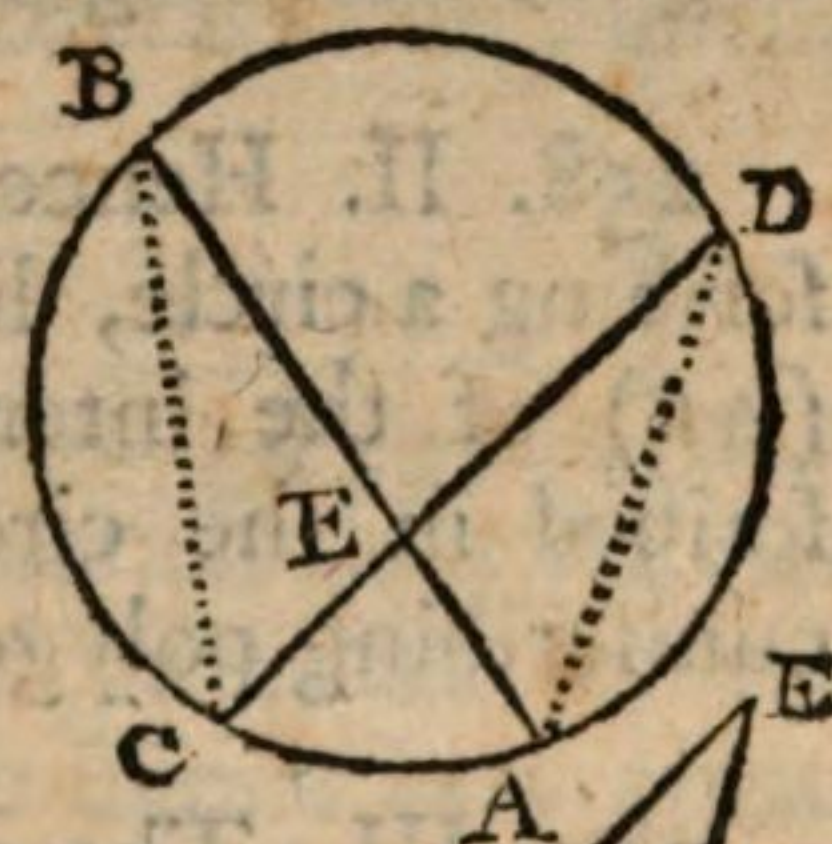
Then the triangles DEA, BEC, are similar.

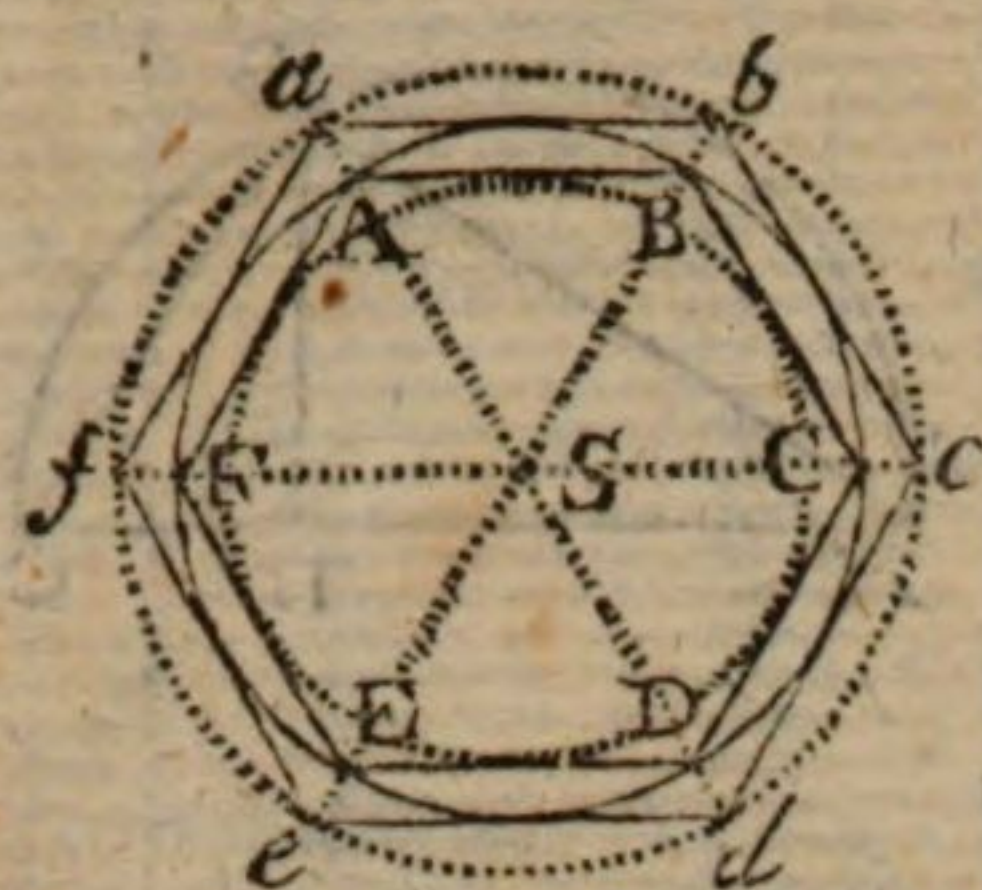
For the angle at E is equal (183) or common.

And the $\angle D = \angle B$, as standing on the same arc AC (212). Then the other angles are equal. (188)

Therefore $AE : CE :: ED : EB$. (250)

Consequently $AE \times EB = CE \times ED$. (245)





256. THEOREM XXIX.

If a regular polygon ($ABCDEF$) be inscribed in a circle; and parallel to these sides if tangents to the circle be drawn, meeting one another (in the points a, b, c, d, e, f); then shall the figure formed by these tangents, circumscribe the circle, and be similar to the inscribed figure.

DEM. Since the circle touches every side of the figure $abcdef$, by construction; therefore the circle is circumscribed by that figure.. (132)

Thro' A and B , draw the radii sA, sB , prolonged till they meet the tangent ab , in a, b .

Then the triangles ASB, asb , are equiangular.

For the $\angle s$ is common; and the other angles are equal, because AB and ab are parallel, by supposition.

Also $sa = sb$: For the triangles ASB, asb , are Isosceles. (194)

And the same may be proved of the other triangles; and also, that they are equal to one another.

Therefore the figure $abcdef$ has equal sides, and is equiangular to the figure $ABCDEF$.

Now $SA : sa :: AB : ab$; And $SA : sa :: AF : af$. (250)

Therefore $AB : ab :: AF : af$. And the like of the other sides. (238)

Consequently the figures $ABCDEF, abcdef$ are similar.

257. COROL. I. If two figures are composed of like sets of similar triangles, those figures are similar.

258. II. Hence, If from the angles (a, b) of a regular polygon circumscribing a circle, lines (as, bs) be drawn to the centre (s); the chords (AB) of the intercepted arcs, will be the sides of a similar polygon inscribed in the circle; and the sides (AB, ab) of the inscribed and circumscribing polygons will be parallel.

259. III. The chords or tangents of like arcs in different circles, are in the same proportion as the radii of those circles.

For if a circle circumscribe the polygon $abcdef$; then the sides of the polygons $abcdef, ABCDEF$, are chords of like arcs in their respective circumscribing circles.

And if a circle be inscribed in the polygon $ABCDEF$, the sides $AB, ab, \&c.$ are tangents of like arcs also: And these have been shewn to be proportional to their radii sA, sa .

260. IV. The Perimeters of like polygons (or the sum of their sides) are to one another as the radii of their inscribed or circumscribed circles.

For $SA : sa :: AB : ab$. (256)

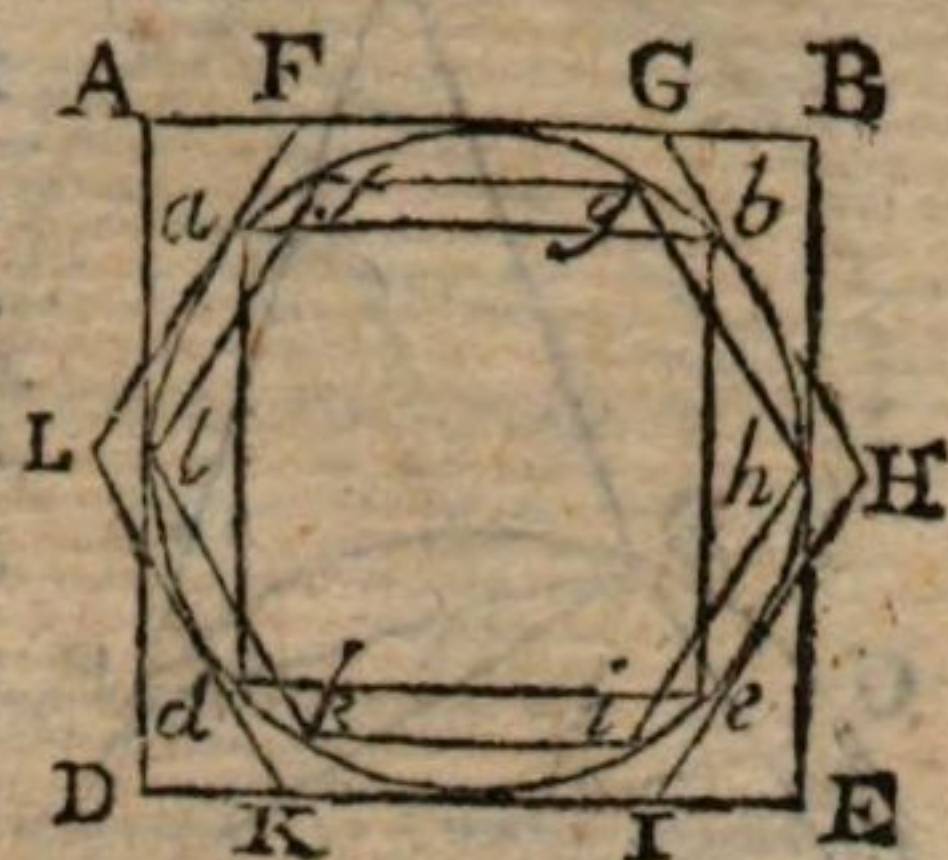
And AB, ab , are like parts of the perimeters of their polygons.

Therefore $SA : sa :: \text{perim. } ABCDEF : \text{perim. } abcdef$. (234)

261.

THEOREM XXX.

If there be two regular and like polygons, the one inscribed in, and the other circumscribing the same circle: Then will the circumference of that circle, and half the sum of the perimeters of these polygons, approach nearer to equality, as the number of sides in the polygons increase.



DEM. It is evident at sight, that the circumscribing hexagon $FGHIKL$ is less than the circumscribing square $ABED$.

And also that the inscribed hexagon $fgbhikl$ is greater than the inscribed square $abed$.

And in both cases, the difference between the hexagon and the circle, is less than the difference between the circle and the square.

Therefore the polygon, whether inscribed or circumscribed, differs less from the circle, as the number of its sides is increased.

And when the number of sides in both is very great, the perimeters of the polygons will nearly coincide with the circumference of the circle; for then the difference of the polygonal perimeters becomes so very small, that they may be esteemed as equal.

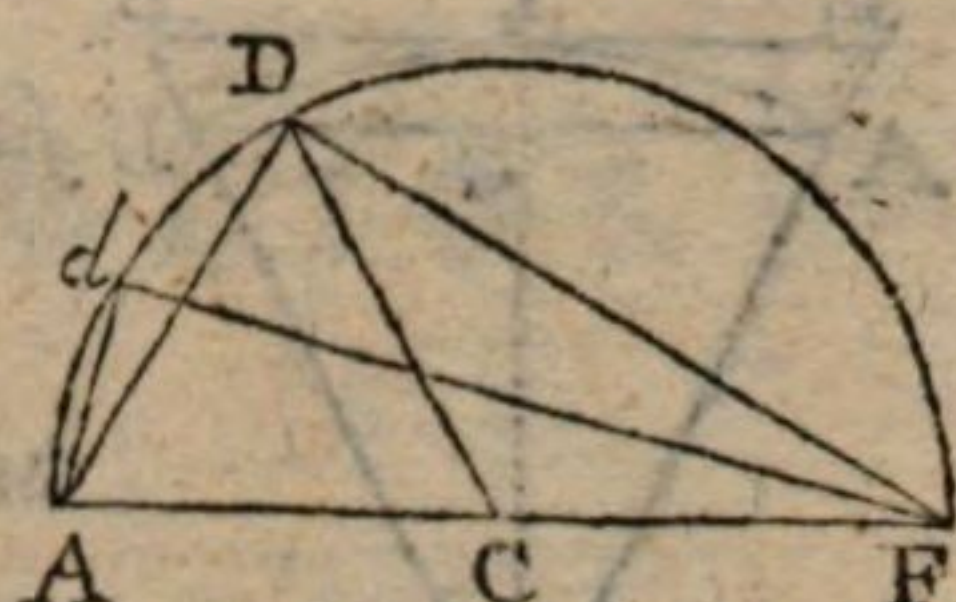
And yet so long as there is any difference between these polygons, tho' ever so small, the circle is greater than the inscribed, and less than the circumscribed polygons: Therefore half their sums may be taken for the circumference of the circle, when the number of those sides is very great.

262. Hence, The circumferences of circles are in proportion to one another, as the radii of those circles, or as their diameters.

For the perimeters of the inscribed and circumscribing polygons are to one another as the radii of the circles. (260)

And these perimeters and circumferences continually approach to equality.

266. EXAMPLE. Required the chord of the $\frac{1}{3072}$ part of the circumference of a circle whose radius is 1. Or, Required the side of a regular polygon of 3072 sides, inscribed in a circle whose diameter is 2.



Let ADF be a semicircle, whose diameter AF = 2, and centre is c. Take the arc AD = $\frac{1}{3}$ of the semicircumference, or equal to 60 degrees; and draw DC, DA, DF.

Let d represent the point where the arc is bisected; dF the supplemental chord to that bisection: And let the marks d' , d'' , d''' , d^{iv} &c. express the bisected points agreeable to the number of bisections.

267. Now since $\angle ACD = 60^\circ$; therefore $\angle CAD + \angle ADC = (180^\circ - 60^\circ =) 120^\circ$. (188)

But $\angle CAD = \angle ADC$ (194); then $\angle CAD = (\frac{1}{2} 120^\circ =) 60^\circ$. Therefore DA = (DC = AC =) 1.

And as the triangle ADF is right angled at D. (213)

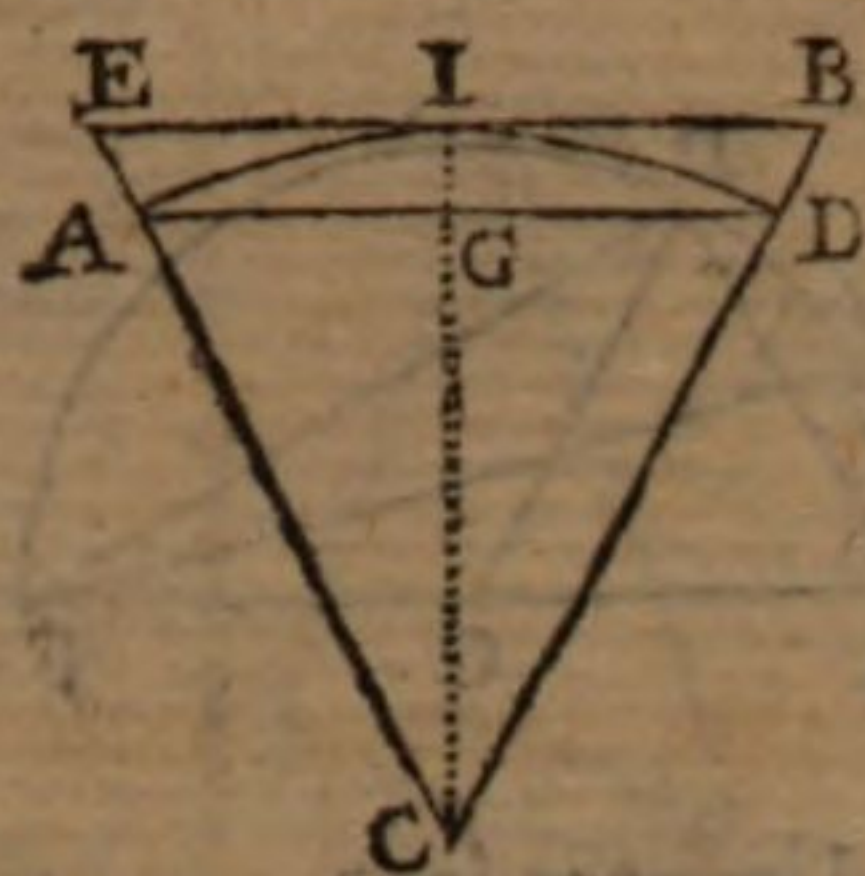
Then $DF = (\sqrt{AF^2 - AD^2} \text{ (203)} = \sqrt{4 - 1} =) \sqrt{3} = 1,7320508075688773$
Therefore the supplemental chord of the arc AD, or of

$\frac{1}{3}$ of the semicircumference is FD	$= \sqrt{3}$	$= 1,7320508075688773$
$\frac{1}{6}$ of the same (264)	is $Fd^i = \sqrt{2 + FD}$	$= 1,9318516525781366$
$\frac{1}{12}$	$Fd^{ii} = \sqrt{2 + Fd^i}$	$= 1,9828897227476208$
$\frac{1}{24}$	$Fd^{iii} = \sqrt{2 + Fd^{ii}}$	$= 1,9957178464772070$
$\frac{1}{48}$	$Fd^{iv} = \sqrt{2 + Fd^{iii}}$	$= 1,9989291749527313$
$\frac{1}{96}$	$Fd^v = \sqrt{2 + Fd^{iv}}$	$= 1,9997322758191236$
$\frac{1}{192}$	$Fd^{vi} = \sqrt{2 + Fd^v}$	$= 1,9999330678348022$
$\frac{1}{384}$	$Fd^{vii} = \sqrt{2 + Fd^{vi}}$	$= 1,9999832668887013$
$\frac{1}{768}$	$Fd^{viii} = \sqrt{2 + Fd^{vii}}$	$= 1,9999958167178004$
$\frac{1}{1536}$	$Fd^{ix} = \sqrt{2 + Fd^{viii}}$	$= 1,9999989541791767$

Now Fd^{ix} the supplemental chord of $\frac{1}{1536}$ being known; the chord Ad^{ix} of $\frac{1}{1536}$ part of the semicircumference, or of $\frac{1}{3072}$ part of the whole circumference, is also known.

That is $Ad^{ix} = (\sqrt{AF^2 - Fd^{ix^2}} =) \sqrt{4 - 2 + Fd^{ix}} = 0,0020453073606764$

268. Consequently, the side of a regular polygon of 3072 sides inscribed in a circle whose diameter is 2, is 0,0020453073606764



269. The side of a similar polygon circumscribing the same circle, whose centre is C, may be thus found.

Let BE be the side of the circumscribed polygon; and draw BC, EC, cutting the circle in D and A.

Draw DA, and it will be the side of the inscribed polygon; and is parallel to BE. (258)

Draw CI bisecting the angle BCE, and it will bisect BE and DA at right angles (102). And $DG = (\frac{1}{2} DA =) \frac{1}{2} A d^{ix}$.

Then $CG = \sqrt{CD^2 - DG^2} = \sqrt{1 - \frac{1}{2} A d^{ix}^2}$.

But $\frac{1}{2} A d^{ix} = 0,001022653680338$. And its square is 0,00000104582055

Which subtracted from 1 leaves 0,99999895417945

Whose square root, or CG, is equal to 0,99999947708959

Now the triangles CBI, CDG, are similar.

Then $CG : CI :: 2 DG : 2 BI$. (250, 234)

Therefore $(2 BI =) BE = (\frac{2 DG \times CI}{CG} (247) =) \frac{DA}{CG}$; For $IC = 1$.

Or $BE = (\frac{0,0020453073606764}{0,9999994770895883} =) 0,0020453084301895$

which is the side of a regular polygon of 3072 sides circumscribing a circle whose diameter is 2.

270. SCHOLIUM. The side of a regular polygon of 3072 sides, inscribed in a circle whose diameter is 2, is 0,0020453073606764. (268)

Which multiplied by 3072, will give the perimeter of that polygon, which is 6,2831842119979622.

The side of a similar polygon, circumscribing the same circle is 0,0020453084301895. (269)

Which multiplied by 3072, will give for the perimeter of that polygon 6,2831874973420925.

The sum of these perimeters is 12,5663717093400547.

The half sum is 6,28318585 &c.

Which is very nearly equal to the circumference of a circle whose diameter is 2 (261), the difference between it

{ and the inscribed polygon being only 0,00000164 &c.

{ and the circumscribed polygon being only 0,00000164 &c.

271. Now the circumferences of circles being in the same proportion, as their diameters. (262)

Therefore the diameter of a circle being 1,

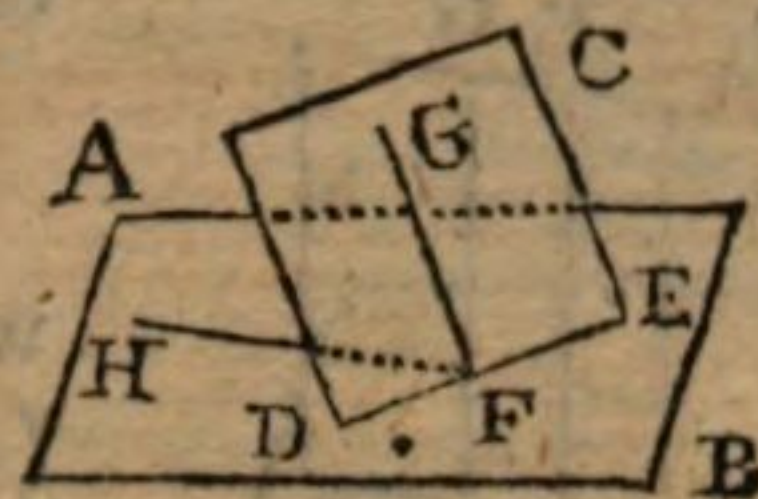
The circumference will be 3,141592 &c. which agrees with the circumference as found by other methods.

SECTION V.
OF PLANES AND SOLIDS.

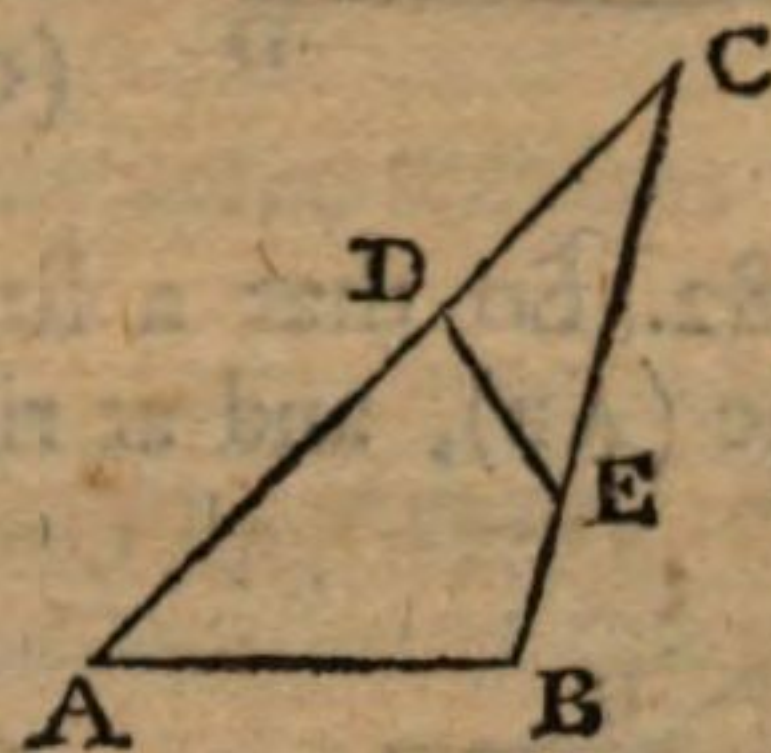
Definitions and Principles.

272. A line is said to be in a plane, when it passes thro' two or more points in that plane.

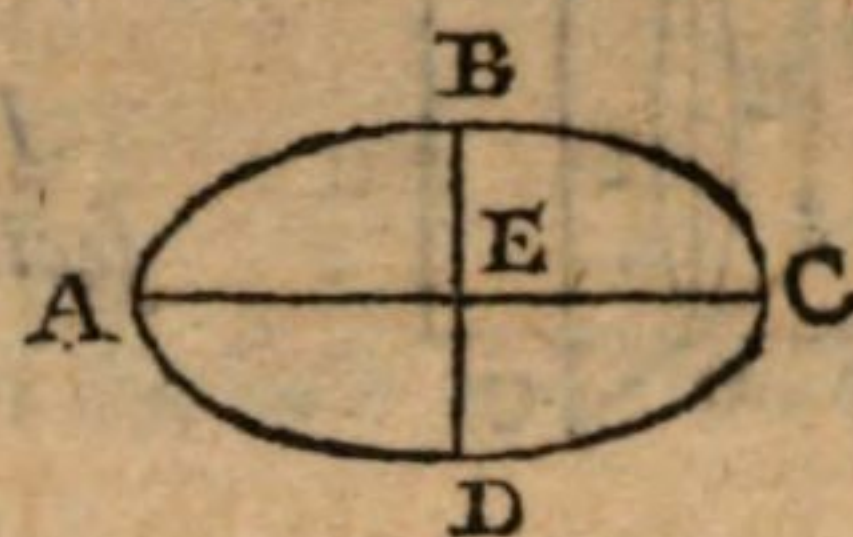
273. The inclination of two meeting planes (AB), (CD), is measured by an acute angle (GFH), made by two right lines (FG, FH), one in each plane, and both drawn perpendicular to their common section (DE), from (F) some point therein.



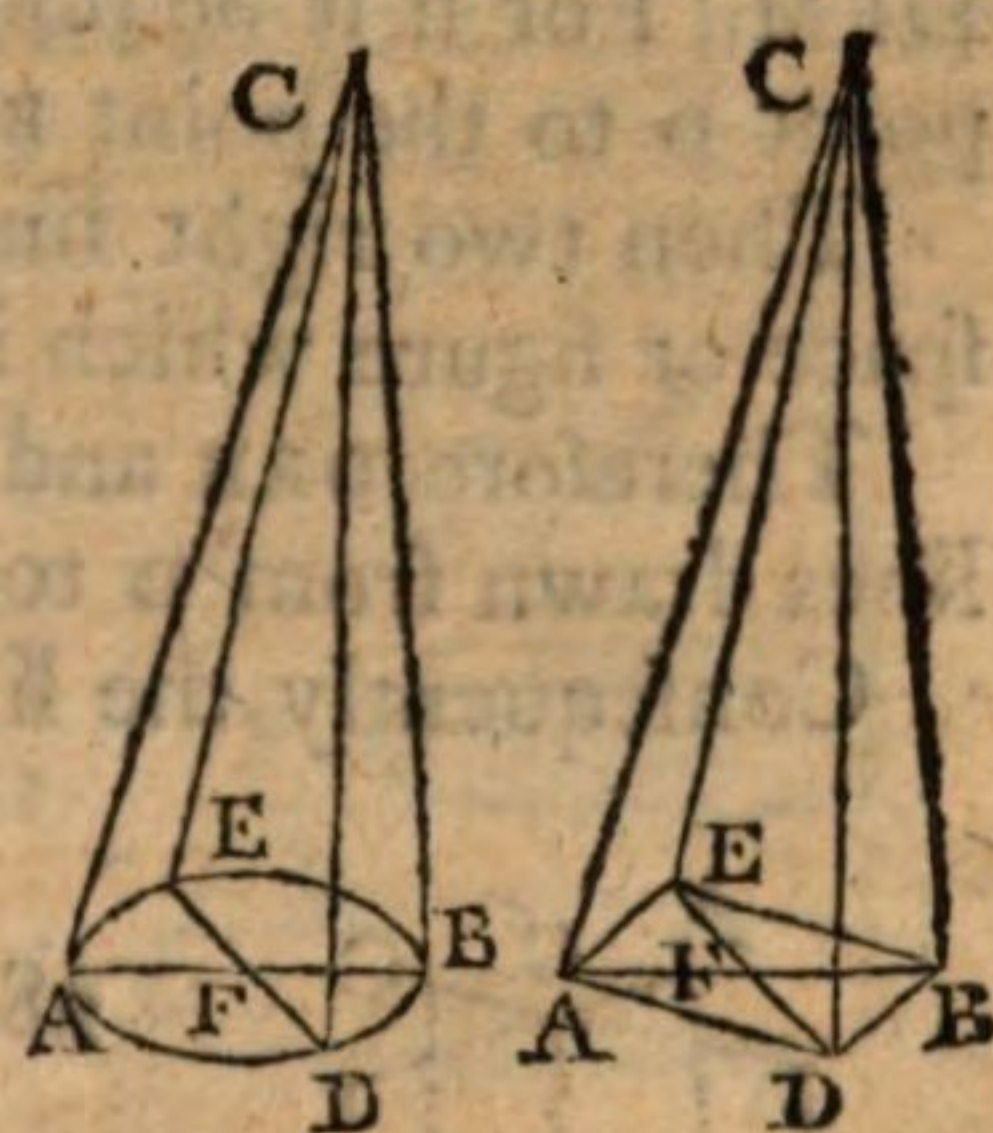
274. A right line (DE) intersecting two sides (AC, BC), of a triangle (ABC), so as to make angles (CDE, CED), within the figure, equal to the angles (CBA, CAB) at the base (AB), but with contrary sides of the triangle, is said to be in a subcontrary position to the base.



275. If a circle in an oblique position be viewed, it will appear of an oval form (as ABCD); that is, it will seem to be longer one way (as AC) than another (as DB); nevertheless the radius's (EA, EB) are to be esteemed as equal: And the same must be understood in viewing of any regular figure when placed obliquely to the eye.



276. If a line be fixed to any point (c) above the plane of a circle (ADBE), and this line while stretched be moved round the circle, so as always to touch it; then a solid which would fill the space passed over by the line, between the circle and the point c, is called a CONE.



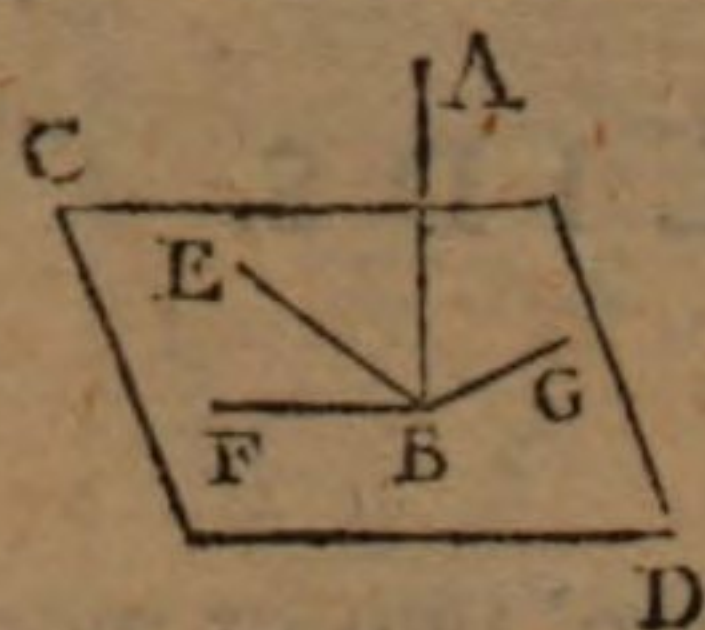
277. If the figure ADBE had been a polygon, and the stretched line had moved along its sides, the figure which would then have been described, is called a PYRAMID.

So that Cones and Pyramids are solids which regularly taper from a circle, or polygon, to a point.

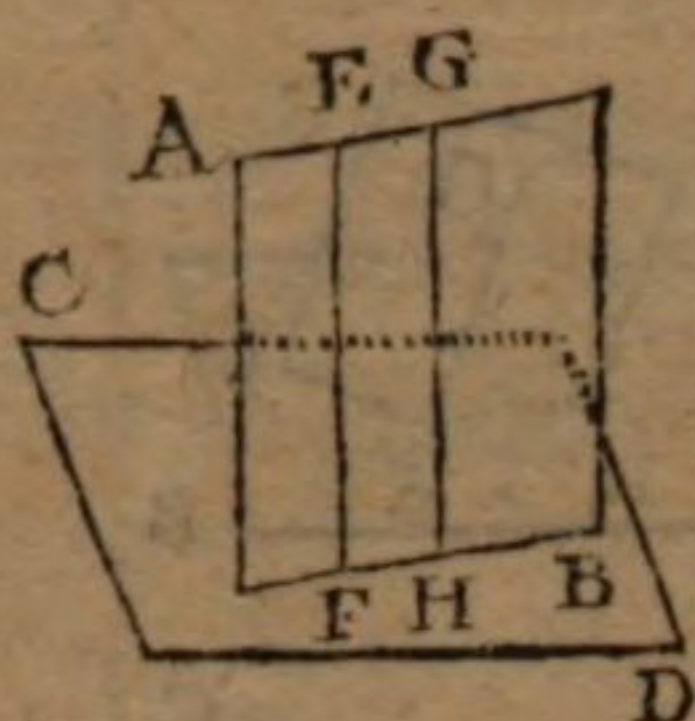
The circle or polygon is called the *Base*; and the point c the *Vertex*.

When the vertex is perpendicularly over the middle or centre of the base, then the solid is called a RIGHT CONE, or a RIGHT PYRAMID; otherwise, an OBLIQUE CONE, or OBLIQUE PYRAMID.

278. If a Cone or Pyramid be cut by a plane passing thro' the vertex c, and centre of the base F, the section ABC, or EDC, is a triangle.



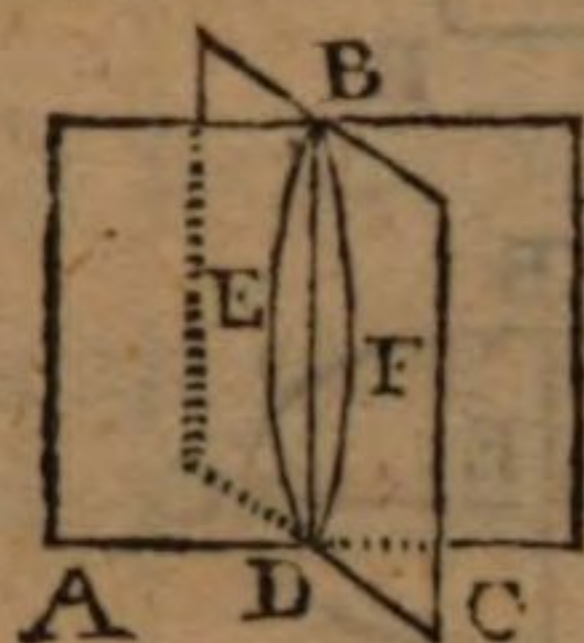
279. A right line (AB) is perpendicular to a plane (CD) when it makes right angles (ABE, ABF, ABG) with all the right lines (BE, BF, BG) drawn in that plane to touch the said right line (AB).



280. So that from the same point (B) in a plane, only one perpendicular can be drawn to that plane, on the same side.

281. A plane (AB) is perpendicular to a plane (CD), when the right lines (EF, GH) drawn in one plane (AB) at right angles to (FB), the common section of the two planes, is also at right angles to the other plane (CD).

282. So that a line (EF) perpendicular to a plane (CD), is in another plane (AB), and at right angles to (FB) the section of the two planes.



283. THEOREM XXXII.

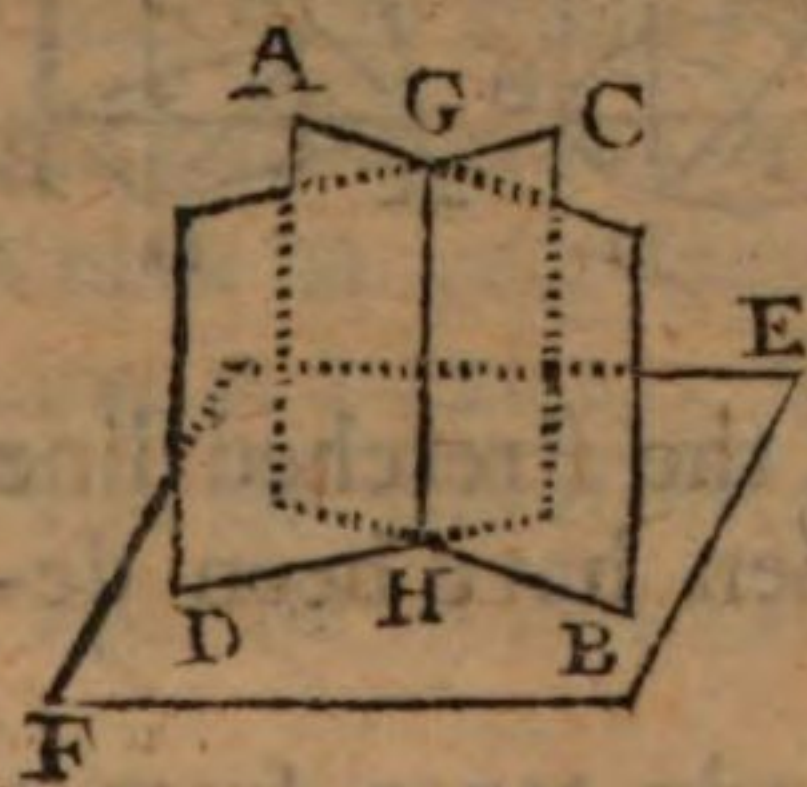
If two planes (AB, CB) cut each other, their common section (BD) will be a right line.

DEM. For if it be not, draw a right line DEB in the plane AB, from the point D to the point B; also draw a right line DFB in the plane BC.

Then two right lines DEB, DFB, have the same terms, and include a space or figure which is absurd. (98)

Therefore DEB and DFB are not right lines: Neither can any other lines drawn from D to B, besides BD, be right lines.

Consequently the line DB the section of the planes, is a right line.



284. THEOREM XXXIII.

If two planes (AB, CD), which are both perpendicular to a third plane (EF), do cut one another; their intersection (HG) is at right angles to that third plane (EF).

DEM. For the common section of AB and CD is a right line (GH) (283): Also HB, HD, are the sections of AB, CD, with the plane EF.

Now from the point H, a line HG drawn perpendicular to the plane EF, must be at right angles to HB, HD. (279)

But HG must be in both planes AB, CD. (282)

Therefore it must be in the sections of those planes.

Consequently the section HG of the planes AB, CD, is at right angles to the plane EF.

285. THEOREM XXXIV.

The sections (*a e b d*) of a Cone or Pyramid (*CAEBD*), which are parallel to the base (*AEBD*), are similar to that base.

DEM. For let *AFBC*, *DFEC*, be sections thro' the vertex *C*, and centre *F* of the base.

Then these sections will cut one another in the right line *FC* (283), and the transverse section *a d b e* in the right lines *a b*, and *e d*, intersecting in *f*.

Then are the following sets of triangles, similar: namely *AFC*, *a f c*; *BFC*, *b f c*; *DFC*, *d f c*; *EFC*, *e f c*.

Wherefore $FC : f c :: FA : f a$
 $FC : f c :: FB : f b$
 $FC : f c :: FD : f d$
 $FC : f c :: FE : f e$ } And the like in any other sections thro' *C* and *F*. (248)

Now in the Cone, $FA = FB = FD = FE$; therefore $f a = f b = f d = f e$. (241)
 So that all the right lines drawn from *f* to the circumference of the figure *a d b e* are equal to one another.

Consequently the figure *a d b e* is a circle. (100)

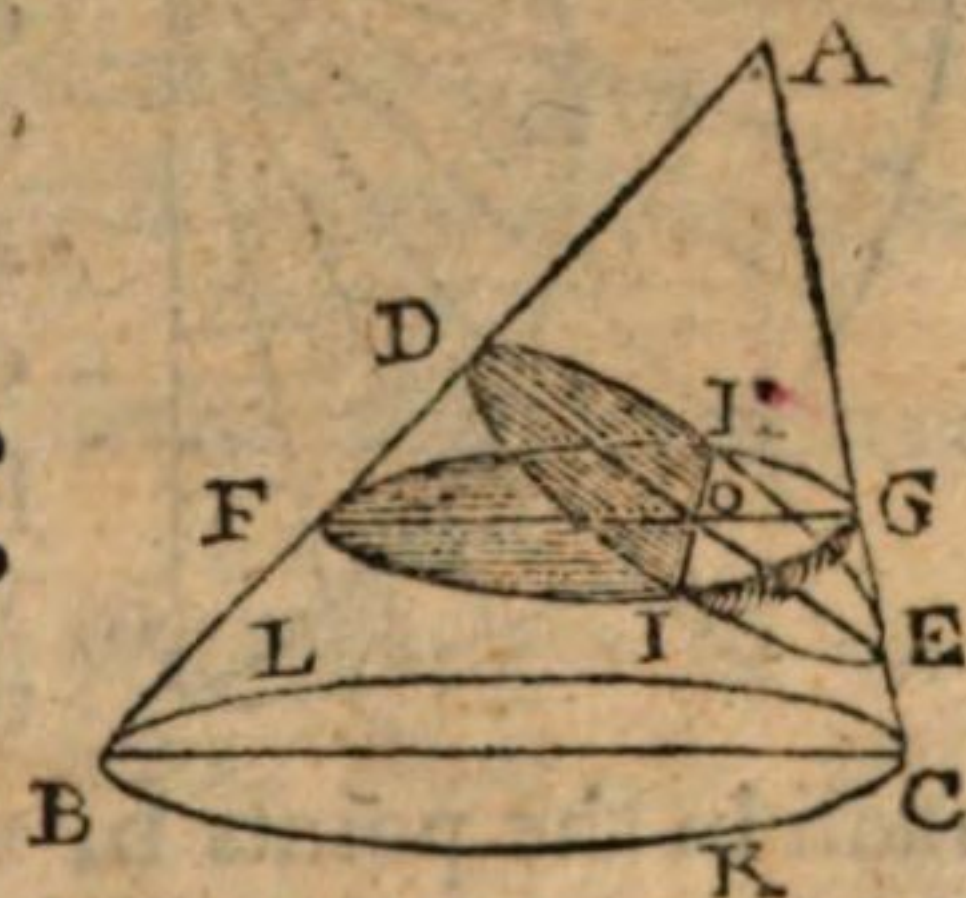
And in the Pyramid, $FC : f c :: DC : d c :: DB : d b :: DA : d a$.
 $FC : f c :: EC : e c :: EA : e a :: EB : e b$.

Therefore in each pair of corresponding triangles in the base and transverse section, the sides are respectively proportional.

Consequently, as the base and transverse section are composed of like sets of similar triangles; therefore they are also similar. (257)

286. THEOREM XXXV.

If a Cone (*ABLCK*) whose base is a circle (*BLCK*), be cut by a plane in a subcontrary position to the base, the section (*DIEH*) will be a circle.



DEM. Thro' the vertex *A*, and centre of the base, let the triangular section *ABC* be taken so as to be at right angles to the planes of the base *BKCL*, of the subcontrary section *DIEH*, and of the section *FIGH* taken parallel to the base and cutting the subcontrary section in the line *IOH*.

Therefore *IOH* is perpendicular to *DE* and *FG* (284) cutting one another in *O*.

Now the section *FIGH* is a circle (285). Therefore $FO \times OG = \overline{OI}^2$ (254).
 Again. The triangles *GOE*, *FOD*, are similar.

For $\angle GEO = \angle DFO = \angle ABC$ by constr. And $\angle GOE = \angle DOF$. (183)

Therefore $EO : OG :: FO : DO$ (250). And $EO \times DO = FO \times OG$ (255) $= \overline{OI}^2$

So that *OI* is a mean proportional, either between *FO* & *OG*, or *DO* & *EO*.

But as the same would happen wherever *FG* cuts *DE*; therefore all the lines *OI*, both in the sections *FIGH* & *DIEH*, are lines in a circle.

Consequently the section *DIEH* is a circle.

SECTION

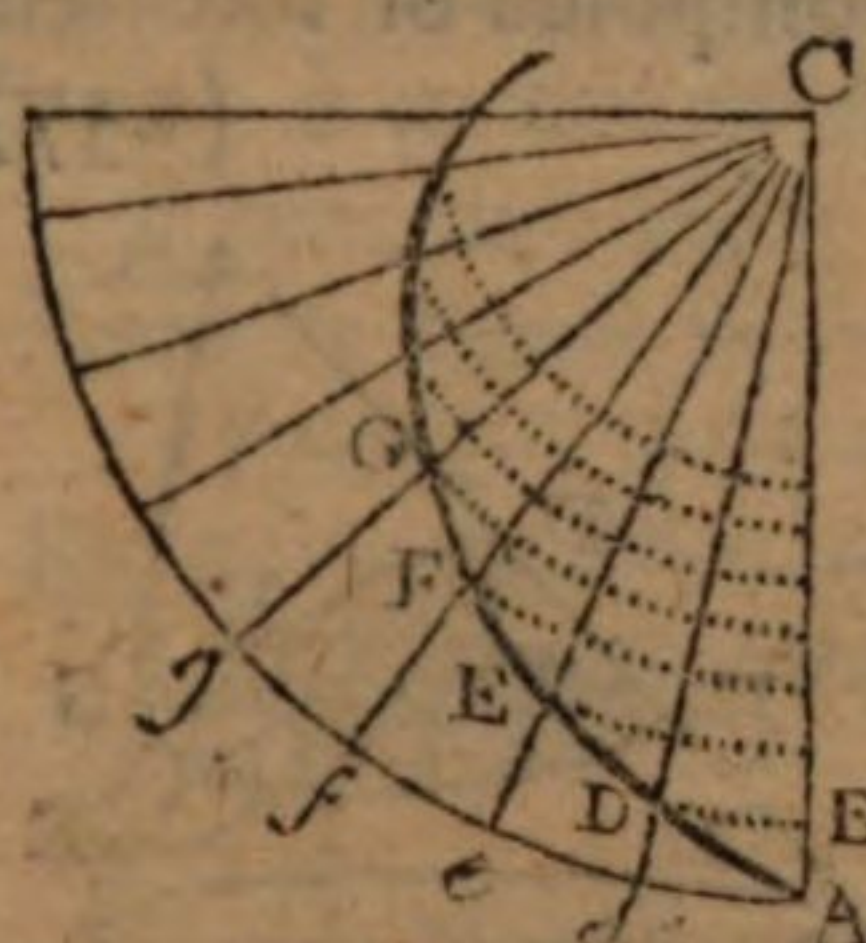
SECTION VI. OF THE SPIRAL.

287. Suppose the radius of a circle to revolve with an uniform motion round its centre, and while it is revolving, a point is moving along the radius; then will the successive places of that point be in a curve which is called a spiral.

This will be readily conceived by imagining a fly to run along the spoke of a wheel, while the wheel is turning round.

If while the radius revolves once, the point has moved the length of the radius; then the spiral will have revolved but once round the centre, or pole; consequently the motion in the circumference is to the motion in the radius, as the circumference is to the radius: And if the wheel revolves twice, thrice, or in any proportion to the motion in the radius; then the spiral will make so many turns, or parts of a turn, round the centre.

288. Now suppose while the radius revolves equably, if a point from the circumference moves towards the centre, with a motion decreasing in a geometric progression; then will a spiral be generated which is called a proportional spiral.



Let the radius CA be divided in any continued decreasing geometric progression, as of 10 to 8; then the series of terms will be 10; 8; 6,4; 5,12; 4,096; 3,2768; 2,62144 &c. Also let the circumference be divided into any number of equal parts, in the points *d, e, f, g*, &c. Then if the several divisions of the radius CA, be successively transferred from the centre C, cutting the other radii in the points D, E, F, G, &c. and a curved line be evenly drawn thro' those points, it will be a spiral of the kind proposed.

289. From the nature of a decreasing geometric progression, it is easy to conceive that the radius CA may be continually divided; and altho' each successive division becomes shorter than the next preceding one, yet there must be an indefinite number of divisions, or terms, before the last of them becomes of no finite magnitude.

290. Hence it follows, that this spiral winds continually round the centre, and does not fall into it till after an indefinite number of revolutions.

Also, that the number of revolutions decrease, as the number of the equal parts into which the circumference is divided, increases.

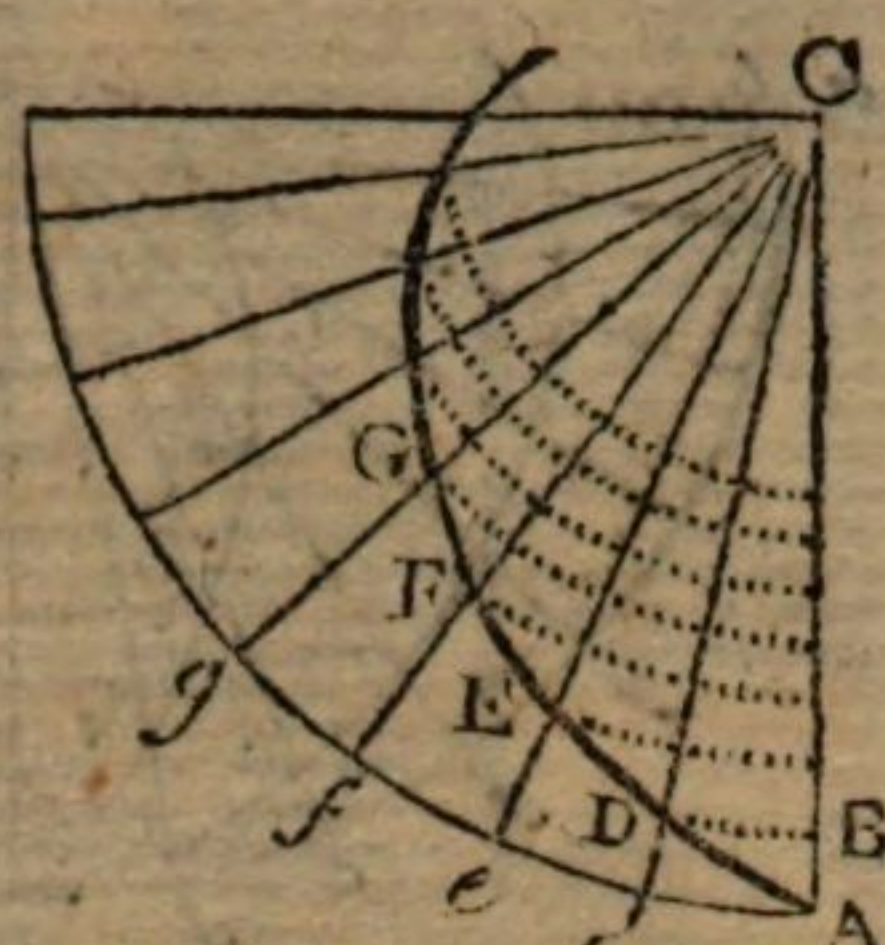
291. THEOREM XXXVI.

Any proportional spiral cuts the intercepted radii at equal angles.

DEM. If the divisions $A d, de, ef, fg, \&c.$ of the circumference were very small, then would the several radii be so close to one another, that the intercepted parts $AD, DE, EF, FG, \&c.$ of the spiral might be taken as right lines.

And the triangles $CAD, CDE, CEF, \&c.$ would be similar, having equal angles at the point C , and the sides about those angles proportional. (251)

Therefore the angles at $A, D, E, F, \&c.$ being equal, the spiral must necessarily cut the radii at equal angles.



292. THEOREM XXXVII.

If the radii of any proportional spiral be taken as numbers, then will the corresponding arcs of the circle, reckoned from their commencement, be as the logarithms of those numbers.

DEM. As the lines $CA, CD, CE, CF, CG, \&c.$ are a series of terms in geometric progression; and the arcs $A d, A e, A f, A g, \&c.$ are a series of terms in arithmetic progression; therefore these arcs may serve (70) as the indices to the geometric terms, and be thus placed;

<i>Radii of the spiral</i>	$CA, CD, CE, CF, CG, \&c.$	Geometric terms.
<i>Corresponding arcs</i>	$0, A d, A e, A f, A g, \&c.$	Arith. terms or indices.

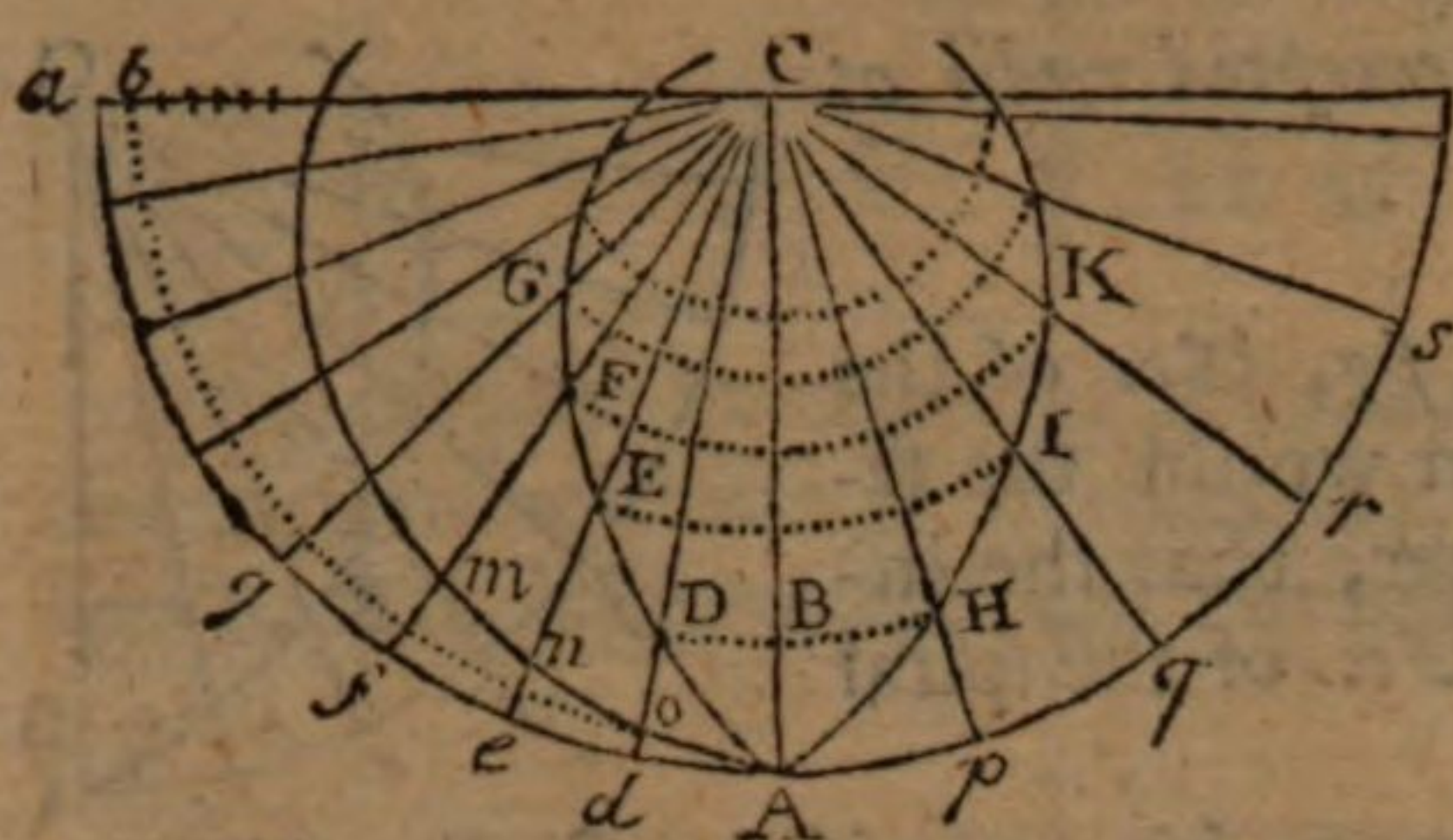
In this disposition, the first term CA , is not distant from itself, therefore its index is represented by 0.

Then if the distance of the second term CD from the first term CA be expressed by the arc $A d$; the distance of the third term CE , from CA , will be expressed by the arc $A e$; and so of the rest.

Consequently, if the terms in the geometric series be represented by numbers, taken as parts of the radius, then the numbers, of the same kind, expressing the measures of the arcs, or indices, will be as the logarithms of the geometric terms. (73)

293. COROL. If the difference between CA and CB was indefinitely small, or CA and CB were nearly in a ratio of equality; then might the number of proportional lines into which CA could be divided, be so many, that any proposed number might be found among the terms of this series; and if the number of parts in the circumference was increased in like manner, then would every term of the proportional division of the radius CA , have its corresponding index among the equal divisions of the circumference; and consequently would exhibit the logarithms of all numbers.

THEOREM XXXVIII.



There may be an almost infinite variety of proportional spirals, and as many different kinds of logarithms.

DEM. For with the same equal divisions Ad , de , ef , &c. of the circumference, every variation in the ratio of CA to CB , as of ca to cb , will produce a different spiral $Aonm$.

And with the same divisions of the radius CA , and different sets of equal parts Ad , de , ef , &c. and Ap , pq , qr , &c. of the circumference, may be formed different spirals $ADEF$, $AHIK$.

Also varying at the same time, both the divisions of the radius and circumference, different spirals will be produced.

But the variations in these three cases may be almost infinite: Therefore the number of such spirals are almost infinite.

Now it is evident that there is a peculiar relation between the rays of any spiral, and the corresponding arcs of the circle; that is, between the terms of a geometric progression and its indices: Therefore there may be as many kinds of logarithms as there are proportional spirals.

THEOREM XXXIX.

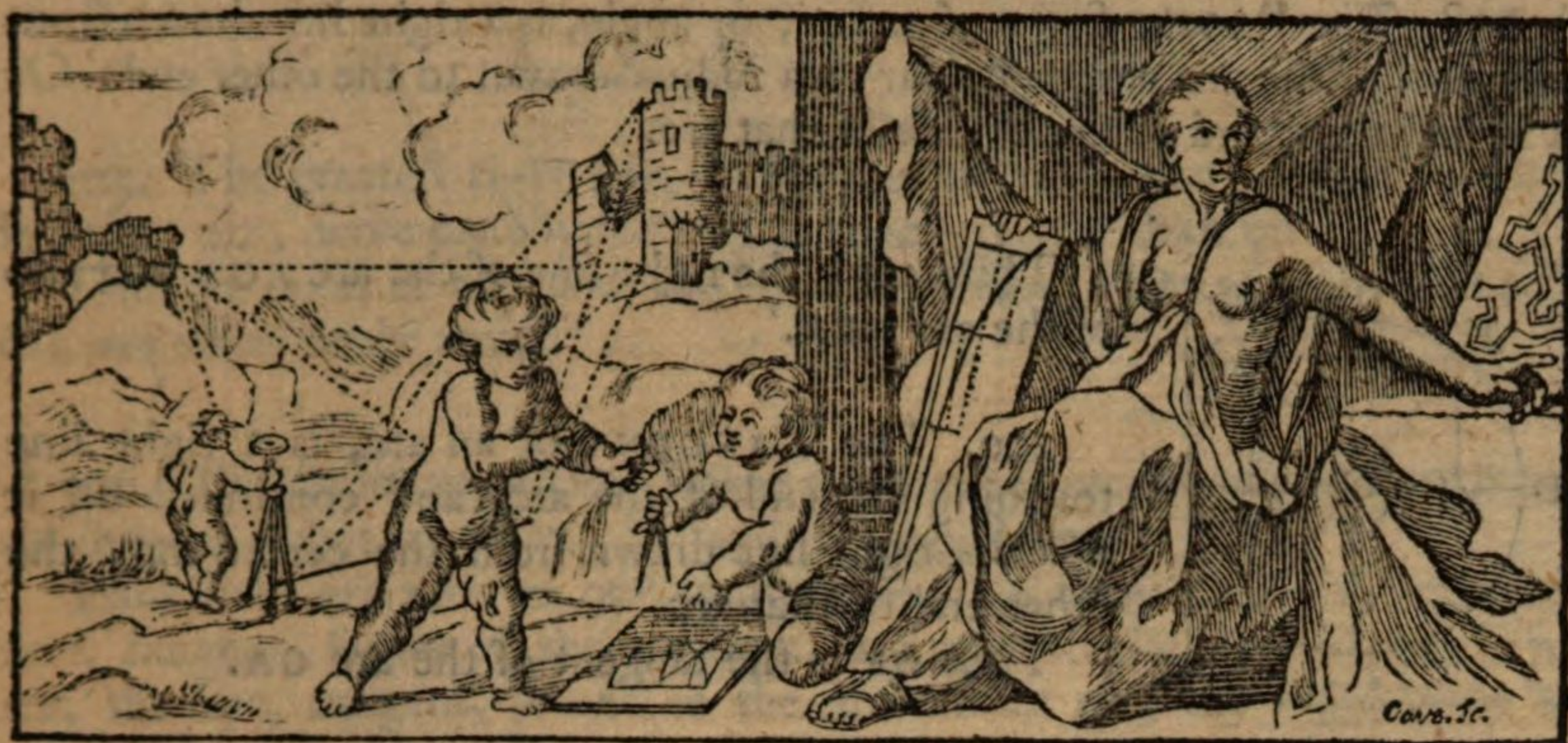
That proportional spiral which intersects equidistant rays at an angle of 45 degrees, produces logarithms that are of Nepier's kind.

DEM. Suppose AB , the difference between CA and CB , the first and second terms of the geometric progression, to be indefinitely small, and take Ap , the logarithm of CB , equal to AB ; then may the figure $ABHp$ be taken as a square, whose diagonal AH would be part of the spiral $AHIK$, and the angle BAH would be half a right one, or 45 degrees.

Therefore that spiral which cuts its rays CA , CH , &c. at angles of 45 degrees, has a kind of logarithms belonging to it, so related to their corresponding numbers, that the smallest variation between the first and second numbers, is equal to the logarithm of the second number.

But of this kind were the first logarithms made by Lord *Nepier*.

Therefore the logarithms to the spiral which cuts its equidistant rays at an angle of 45 degrees, are of the *Nepierian* kind.



THE
ELEMENTS
OF
NAVIGATION.

BOOK III.
OF PLANE TRIGONOMETRY.

SECTION I.

Definitions and Principles.

296. **P**LANE TRIGONOMETRY is an art which shews how to find the measures of the sides and angles of plane Triangles, some of them being already known.

It will be proper for the learner, before he reads the following Articles, to turn to the definitions relative to a circle and angle, contained in the Articles 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, and 127.

297. A Triangle consists of six parts; namely, three sides and three angles.

The sides of plane triangles are denoted or estimated by measures of length; such as Feet, Yards, Fathoms, Furlongs, Miles, Leagues, &c.

The angles of triangles are estimated by circular measure, that is, by arcs containing Degrees, Minutes, Seconds, &c. (106); and for convenience these circular measures are represented by right lines, called right sines, tangents, secants, and versed sines.

A X I O M S.

305. The greatest right fine, is the fine of 90° ; and the fines to arcs less than 90° , serve equally for arcs as much greater than 90° .

Thus the fines of 80° and 100° ; of 60° and 120° ; of 40° and 140° &c. are respectively equal.

306. The same tangent and secant will serve to arcs equally distant from 90 degrees; that is, to any arc and its supplement.

Thus if the arc $BAG = 90^\circ$, and $BK = BA$; then KM , GL , CL , the fine, tangent, secant of the arc GBK , are respectively equal to AH , GF , CF , the fine, tangent, secant of the arc $GA = DK$, the supplement of the arc GBK .

307. When an arc is greater than 90° ; the fine, tangent, secant, of the supplement is to be used.

308. The chord (AN) of an arc (AGN), is equal to twice (CI) the co-fine of (AB) half the supplemental arc (ABK).

309. The versed fine and co-fine together ($HG + CH$) of any arc (AG), is equal to the radius. CH being equal to AI .

310. The fines, tangents, secants, or versed fines, of similar arcs in different circles, are in the same proportion to one another as the radii of those circles. (259)

311. The angles of two triangles may be respectively equal, altho' their sides may be unequal.

Therefore in a triangle among the things given, in order to find the rest, one of them must be a side.

In Trigonometry, the three things given in a triangle must be either

1st. Two sides and an angle opposite to one of them.

2d. Two angles and a side opposite to one of them.

3d. Two sides and the included angle.

4th. The three sides.

In either case, the other three things may be found by the help of a few Theorems, and a *Triangular Canon*, which is a Table wherein are orderly inserted every degree and minute in a quadrant or arc of 90° degrees; and against them, the measures of the lengths of their corresponding fines, tangents and secants, estimated in parts of the Radius, which is usually supposed to be divided into a number of equal parts, as 10, 100, 1000, 10000, 100000, &c.

SECTION

SECTION II.

Of the Triangular Canon.

PROPOSITION I.

312. To find the lengths of the Chords, Sines, Tangents and Secants to arcs of a circle of a given radius.

CONSTRUCTION. Thro' each end of the given radius CD , and at right angles to it (149) draw the lines CF , DG : On c with the radius CD , describe the quadrantal arc DA , and draw the chord DA .

313. FOR THE CHORDS. Trisect the arc AD (152), and (by trials) trisect each part; then the arc AD will be divided into 9 equal parts of 10 degrees each; if these arcs are divided each into 10 equal parts, the quadrant will be divided into 90 degrees: But in this small figure, the divisions to every 10 degrees only, are retained, as in art. 174.

From D as a centre, with the radius to each division, cut the right line DA ; and it will contain the chords of the several arcs into which the quadrantal arc AD was divided.

For the distances from D to the several divisions of the right line DA , are hereby made respectively equal to the distances or cords of the several arcs reckoned from D .

314. FOR THE SINES. Thro' each of the divisions of the arc AD , draw right lines parallel to the radius AC ; these parallel lines will be the right fines of their respective arcs, and CD will be divided into a line of fines, which are to be numbered from c to D , for the right fines; and from D to c for the versed fines.

For the distances from c to the several divisions of the right line CD , are respectively equal to the fines of the several arcs beginning from A .

315. FOR THE TANGENTS. A ruler on c , and the several divisions of the arc AD , will intersect the line DG ; and the distances from D to the several divisions of DG will be the lengths of the several tangents.

316. FOR THE SECANTS. From the centre c , with radii to the divisions of the tangent DG , cut the line CF ; and the distances from c to the several divisions of CF , will be the lengths of the secants to the several arcs.

For these lengths are made respectively equal to the secants reckoned from c to the several divisions of the tangent DG .



If

317. If the figure was so large that the quadrantal arc could contain every degree and minute of the quadrant, or 5400 equal parts; then the chord, sine, tangent and secant to each of them could be drawn. Now a scale of equal parts being constructed, 1000 of which parts are equal to the radius CD ; then the lengths of the several sines, tangents and secants may be measured from that scale, and entered in a table called the triangular canon, or the table of sines, tangents and secants.

But as these measures cannot be taken with sufficient accuracy to serve for the computations to which such tables are applicable; therefore the several lengths have been calculated for a radius divided into a much greater number of equal parts; as is shewn in the following articles.

318.

P R O P. II.

In any circle, the chord of 60 degrees, is equal to the radius: and the sine of 30 degrees, is equal to half the radius.

DEM. Let the arc CB , or $\angle CAB = 60^\circ$ degrees; and draw the chord CB .

Now since the radii AC and AB are equal; (100)

Therefore $\angle C = \angle B$. (194)

And the $\angle C + \angle B = (180^\circ - (\angle A =) 60^\circ =) 120^\circ$ (186)

Therefore $\angle C$, or $\angle B = (\text{half } 120^\circ; \text{ or } =) 60^\circ = \angle A$.

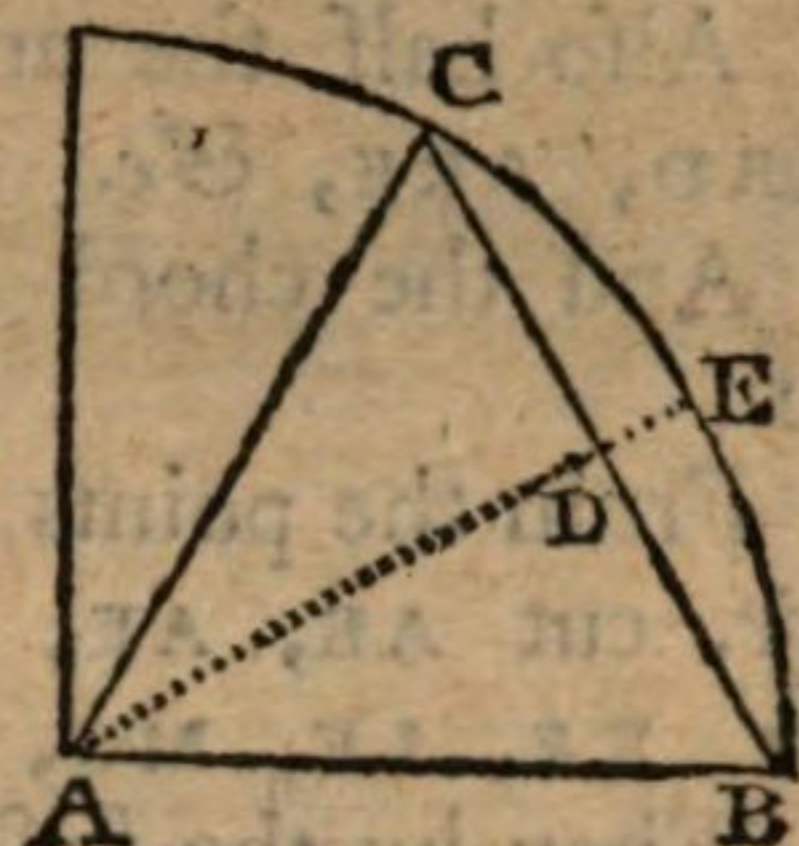
Consequently $CB = AB = AC$.

From A , draw the radius AE perpendicular to CB .

Then AE bisects the arc CB , and its chord. (207)

And $CD = \text{fine of (the arc } CE = \text{half of } 60^\circ =) 30^\circ$. (298)

Consequently CD is equal to half the radius AB .



319. Hence, *Twice the co-sine of 60 degrees is equal to the radius.*

For 30° is the complement of 60° ; and twice the sine of 30 is equal to the radius.

320.

P R O P. III.

To find the sine of one minute of a degree.

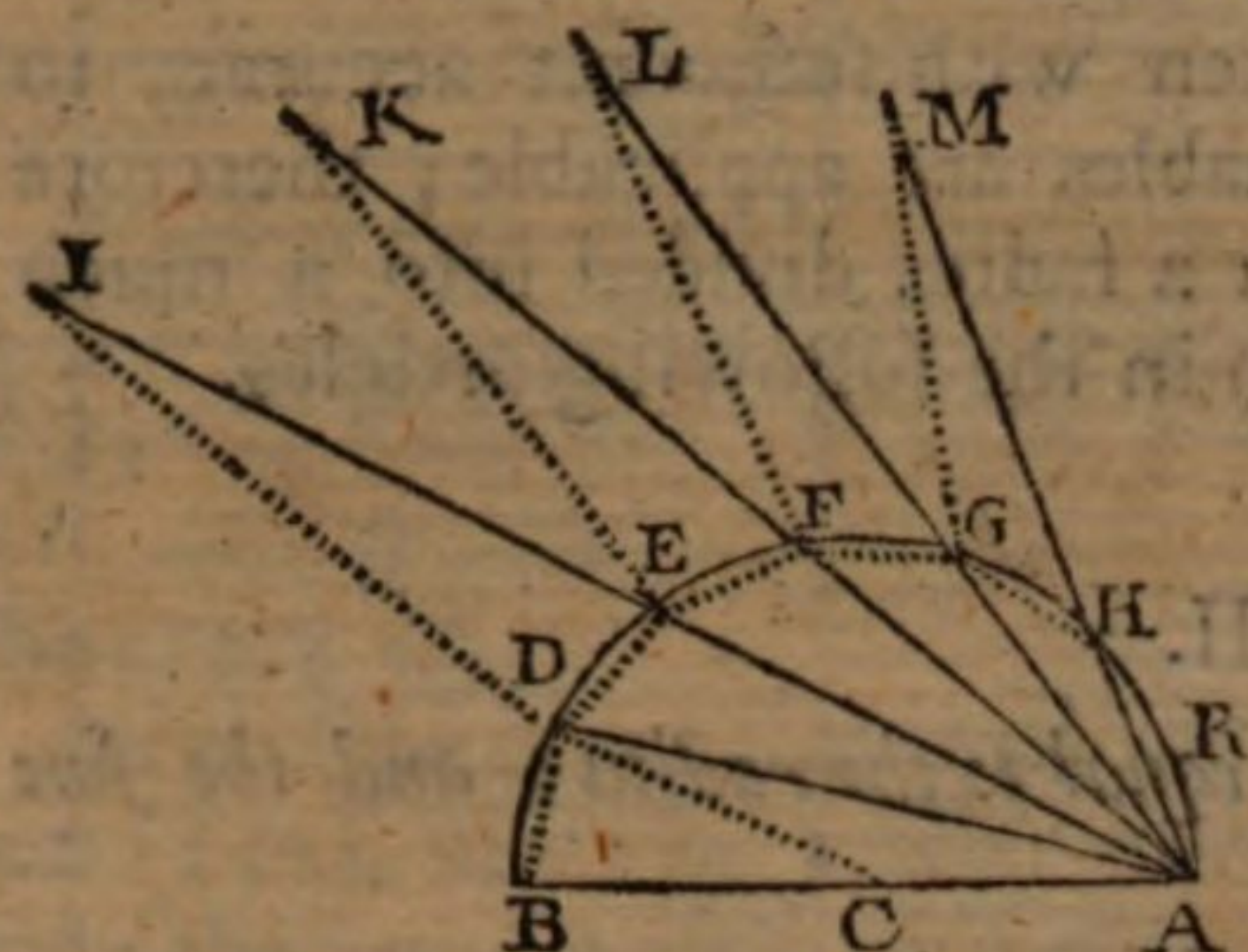
It is evident (261), that the less the arc is, the less is the difference between the arc and its sine, or half chord; so that a very small arc, such as that of one minute, may be reckoned to differ from its sine, by so small a quantity, that they may be esteemed as equal; and consequently may be expressed by the same number of such equal parts of which the radius is supposed to contain 1,00000 &c. which is readily found by the following proportion.

As the circumf. of the circle in minutes	21600
To the circumf. in equal parts of the radius (270)	6,283185
So is the arc of one minute	1,
To the corresponding parts of the radius	0,0002908882
So that for the sine of one minute, may be taken	0,0002908882

321.

PROP. IV.

In a series of arcs in arithmetic progression, the sine of any one of them taken as a mean, and the sum of the sines of any other two, taken as equidistant extremes, are ever in a constant ratio, of radius to twice the co-sine of the common difference of those arcs.



DEM. For in a circumference whose centre is C , and diameter AB , let there be taken a series of arcs, ARB , ARD , ARE , ARF , ARG , ARH , &c. whose common difference is the arc BD .

Then drawing the chords AB , AD , AE , AF , AG , AH , &c. their halves will be the sines of half the arcs ARB , ARD , &c. (298)

Also half the arc BD , is the common difference of half the arcs ARB , ARD , ARE , &c. (233)

And the chord AD is twice the co-sine of half the supplemental arc BD . (308)

From the points D , E , F , G , &c. with the radii DA , EA , FA , GA , &c. cut AE , AF , AG , AH , &c. produced, in I , K , L , M , &c. draw ID , KE , LF , MG , &c. and BD , DE , EF , FG , GH , &c.

Then by the first part of the demonstration to art. 263, the following triangles are congruous, namely,

ABD , IED ; ADE , KFE ; AEF , LGF ; AFG , MHG , &c.

Therefore $IE = AB$; $KF = AD$; $LG = AE$; $MH = AF$, &c.

Also, the triangles IDA , KEA , LFA , MGA , &c. being each of them Isosceles, and their angles respectively equal, are similar to DCA . (250)

Therefore $CA : AD :: (AD : (AI =) AB + AE ::) \frac{1}{2} AD : \frac{1}{2} AB + \frac{1}{2} AE.$
 $:: (AE : (AK =) AD + AF ::) \frac{1}{2} AE : \frac{1}{2} AD + \frac{1}{2} AF.$
 $:: (AF : (AL =) AE + AG ::) \frac{1}{2} AF : \frac{1}{2} AE + \frac{1}{2} AG.$
 &c. &c.

The halves being in the same ratio as the wholes. (233)

322. Consequently, In a series of arcs in arithmetic progression, viz. $\frac{1}{2} ARB$, $\frac{1}{2} ARD$, $\frac{1}{2} ARE$, &c. whose common difference is half the arc BD , it will be,

As (AC) Radius,

To (AD) twice the co-sine of the common difference;

So is the sine of either arc taken as a mean,

To the sum of the sines of two equidistant extremes.

323. Hence; The sine of either extreme, subtracted from the product of the sine of the mean by twice the co-sine of the common difference, will give the sine of the other extreme. (247)

324. When the common difference of the arcs is 60 degrees; then twice the co-sine of its complement is equal to the radius. (319)

And (322) $R : (2 \cos. 60^\circ =) R :: s, 90^\circ : (s, 30^\circ + s, 150^\circ =) s, 30^\circ + s, 30^\circ.$
 $:: s, 85 : (s, 25^\circ + s, 145^\circ =) s, 25^\circ + s, 25^\circ.$
 $:: s, 80 : (s, 20^\circ + s, 140^\circ =) s, 20^\circ + s, 40^\circ.$
 $:: s, 75 : (s, 15^\circ + s, 135^\circ =) s, 15^\circ + s, 45^\circ.$
 $\text{Etc.} \quad \text{Etc.}$ } (305)

Here the first and second terms in the proportions being equal, the third and fourth terms are also equal.

325. Hence, *The sine of an arc greater than 60 degrees, is equal to the sine of an arc as much less than 60 degrees, added to the sine of its difference from 60 degrees.*

Therefore the sines of arcs above 60 degrees, are readily obtained from those under 60 degrees.

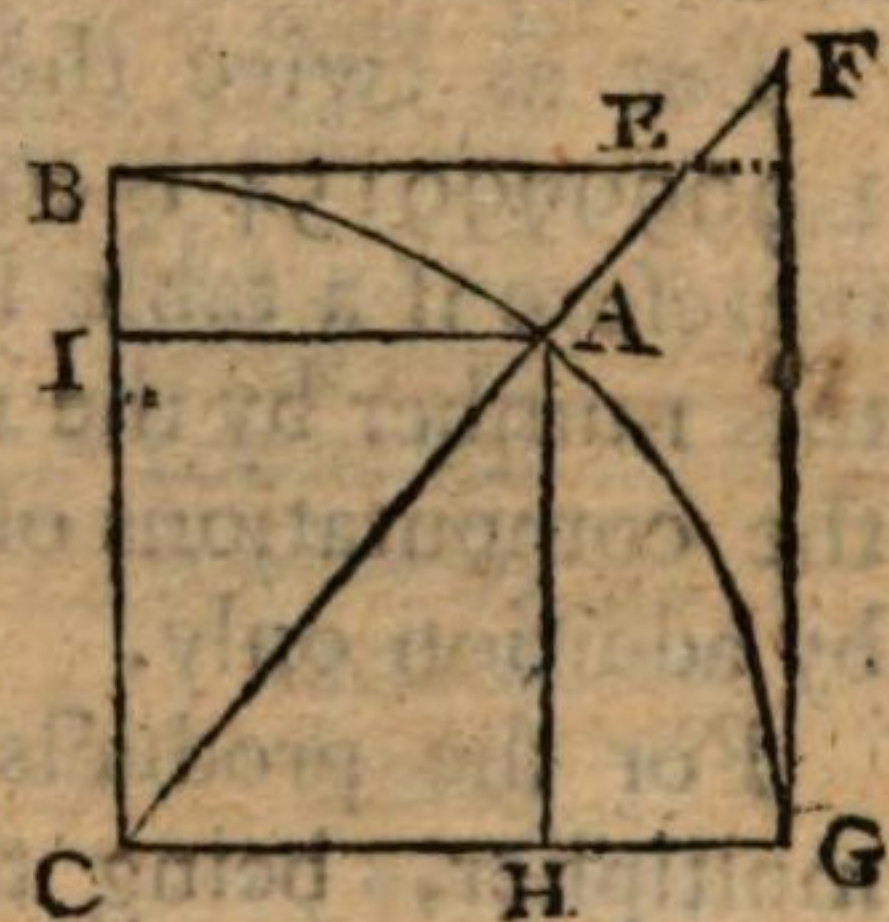
326.

PROP. V.

The right sine of an arc being known, to find its co-sine; and from these, to find the tangent, secant, versed sine; and also the co-tangent, co-secant, and co-versed sine.

Let AG be any arc, and let AH be its sine, AI its co-sine; GF the tangent, BE the co-tangent; CF the secant, CE the co-secant; HG the versed sine, BI the co-versed sine.

Now if the sine AH be given, then the co-sine AI or CH, will be known (203); For $\overline{CA}^2 - \overline{AH}^2 = \overline{CH}^2$. Therefore the square root of the difference between the squares of the radius and sine, will be the co-sine.



327. { Then the versed sine $HG = CG - CH$; and co-versed sine $IB = CB - CI$.
 { And since the triangles CHA, CGF, CBE, are similar,

328. { Therefore (250) $CH : HA :: CG : GF$ the tangent.
 { That is, *As the co-sine to the sine, so is radius to the tangent.*

329. { And $CH : CA :: CG : CF$ the secant.
 { That is, *As the co-sine to the radius, so is the radius to the secant.*

330. { And $CI : CA :: CB : CE$ the co-secant.
 { That is, *As the sine to radius, so is radius to the co-secant.*

331. { Also $CI : IA :: CB : BE$, the co-tangent.
 { That is, *As the sine to the co-sine, so is radius to the co-tangent.*
 { Or $GF : CG :: CB : BE$; that is, *As tangent : rad :: rad : co-tangent.*

332. Hence it is evident, that the tangent and co-tangent of an arc of 45° are equal to one another, and to the radius, or sine of 90 degrees.

And as the square of radius is equal to the rectangle of any tangent and its co-tangent,

Therefore $\tan. \times \cot. = \text{rad.} \times \cot.$ Therefore $\tan. : \text{rad.} :: \cot. : \cot.$ (246)
 Or the tangents of different arcs are reciprocally as their co-tangents.

333. The principles by which the lengths of the fines, tangents, secants, &c. may be constructed, being delivered, the following examples are annexed to illustrate this doctrine.

Required the co-sine of one minute.

The sine of 1 minute being	0,0002908882 (320)
Its square is	0,00000008461594
Which subtracted from the square of radius	1,
Leaves	0,99999991538406
Whose square root	0,9999999577 is the

co-sine of 1 minute; or the sine of $89^{\circ} 59'$.

Now having the sine and co-sine of 1 minute, the other fines may be found in the following manner. (323)

twice the cos. 1 min. $\times$ sine of 1 m. = sum of the fines of $0'$ & $2'$.

twice the cos. 1 min. $\times$ sine of 2 m. = sum of the fines of $1'$ & $3'$.

twice the cos. 1 min. $\times$ sine of 3 m. = sum of the fines of $2'$ & $4'$.

twice the cos. 1 min. $\times$ sine of 4 m. = sum of the fines of $3'$ & $5'$.

twice the cos. 1 min. $\times$ sine of 5 m. = sum of the fines of $4'$ & $6'$.

Proceeding thus in a progressive order from each sine to its next, all the fines may be found.

But as twice the co-sine of 1 minute, viz. 1,9999999154 is concerned in each operation, therefore if a table be made of the products of this number by the nine digits, as here annexed, the computations of the fines may be performed by addition only.

For the products by the digits in the given multiplier, being taken from the table, and wrote in their proper order, will prevent the trouble of multiplication.

Multipliers.	Products.
1	1,9999999154
2	3,9999998308
3	5,9999997462
4	7,9999996616
5	9,9999995770
6	11,9999994924
7	13,9999994078
8	15,9999993232
9	17,9999992386

And even this operation may be very much shortened, by setting under the right hand place (viz. 4) of the double co-sine of one minute, the unit place of the sine used as a multiplier; and reversing, or placing in a contrary order, all its other figures; then the right hand figure of each line arising by the multiplication, is to be set under one another; and in these lines, the first figure to be set down, is what arises from the figure standing over the present multiplying one; observing to add what would be carried from the places omitted,

Now if the products of the figures in the multiplier, thus inverted, be taken from the table of products; it is necessary to remark what number of places will arise from each digit used in the multiplier; then in the products of those digits in the table, take only the like number of places, observing to add 1 to the right hand place, if the next of the omitted figures exceed 5.

Required

Required the sine of 2 minutes.

The sine of 1 min. placed in an inverted order under the double cos. of 1 min. as in the margin; the right hand figure 2 stands under the 9 in the 6th decimal place, therefore the first 6 decimal places of the product against 2 in the table, are to be used; but 1 being added, because the 7th place 8, exceeds 5, makes the product 4000000: Also, for 9 the next figure in the multiplier, standing under the 5th decimal place, take 17,99999 from the table of products, and 1 being added to the 5th place, because the 6th exceeds 5, makes it 18,00000:

1,9999999154
2888092000,0
4000000
1800000
16000
1600
160
4
0,0005817764

In like manner, the product by 8, adding 1, is 16000 &c. and the sum of these products 0,0005817764 is the sine of 2 min. as required.

This kind of operation will be very easily conceived, without farther illustration, by comparing the process in this and the following operations, with what has been already said.

Required the sines of 3', 4', 5', & 6 minutes.

For 3 min.	For 4 min.	For 5 min.	For 6 min.
1,9999999154	1,9999999154	1,9999999154	1,9999999154
4677185000,0	5466278000,0	6255361100,0	5044454100,0
9999999	16000000	19999999	19999999
1600000	1400000	2000000	8000000
20000	40000	1200000	1000000
14000	12000	60000	80000
1400	1200	10000	8000
120	80	1000	800
8	10	40	10
		12	
0,0011635527	0,0017453290	0,0023271051	0,0029088809
0,0002908882	0,0005817764	0,0008726645	0,0011635526
0,0008726645	0,0011635526	0,0014544406	0,0017453283

In each example, the sine of 2 min. less, (323) is subtracted.

The sines being made, the tangents, secants, &c. are to be constructed as before shewn. (327, 328)

334. There are many methods by which the triangular canon may be made; but that which is here delivered was chosen as the most easy, the best adapted to this work, and what would give the learner a sufficient notion how these numbers are to be found: For at this time, there is no occasion to construct new tables of sines, and rarely to examine those already extant; they having passed thro' the hands of a great many careful examiners, and for a long time have been received by the learned as a work sufficiently correct.

These lines were first introduced into mathematical computations by *Hipparchus* and *Menelaus*, whose methods of performance were contracted by *Ptolomy*, and afterwards perfected by *Regiomontanus*; and since his time *Rheticus*, *Clavius*, *Petiscus*, and many other eminent men, have treated largely on this subject, and greatly exemplified the use of this triangular Canon, or Tables; which are now, by way of distinction, called Tables of *natural* fines, tangents, &c. But the greatest improvement ever made in this kind of mathematical learning, was by the Lord *Napier*, Baron of *Merchiston* in *Scotland*; who being very fond of such studies, wherein calculations by the fines, tangents, &c. did frequently occur, judged it would be of vast advantage could these long multiplications and divisions be avoided; and this he effected by his happy invention of computing by certain numbers considered as the indices of others (73), which he called logarithms; this was about the year 1614.

The tables now chiefly used in Trigonometrical computations, are the logarithms of those numbers which express the lengths of the fines, tangents, &c. and therefore to distinguish them from the *natural* ones, they are called *Logarithmic* fines, tangents, &c. (or by some artificial fines, &c.) Only those of the logarithmic fines and tangents are annexed to this treatise, because the business of Navigation may be performed by them; neither are these tables carried to more than five places beside the index, that being sufficiently exact for all nautical purposes: But it must be allowed that, for general use, such tables are the most esteemed, as consist of most places.

335. These tables are so disposed, that each opening of the book contains six degrees; three of which are numbered at top, and three at the bottom of the page; those at top proceed from left to right, or forwards, from 0 degrees to 45; and those at bottom, from right to left, or backwards, from 45 to 90 degrees: To each degree there are four columns, titled fines, tangents, co-fines, co-tangents; and the minutes are in the marginal column of each page, signed with M; those on the left side belong to the degrees at top, and those on the right hand side of the page, to the degrees at bottom.

336. Now a fine, tangent, co-fine, co-tangent, to a given number of degrees, is found as follows.

For an arc less than 45 degrees.

Seek the degree at top, and the minutes in the column signed M at top; against which, in the column signed at top with the proposed name, stands the fine, or tangent &c. required.

But when the arc is greater than 45 degrees,

Seek the degree at bottom, the min. in the column with M at bottom, and the proposed name at bottom.

EXAMPLE

EXAMPLE I. *Required the logarithmic sine of 28°. 37'.*

Find 28 deg. at the top of the page ; and in the side column marked with M at top, find 37 ; against which, in the column signed at top with the word sine, stands 9,68029, the log. sine of 28°. 37'. as required.

EXAMPLE II. *Required the logarithmic tangent of 67°. 45'.*

Find 67 deg. at the bottom of the page ; and in the side column titled M at the bottom, find 45 ; then against this, in the column marked tangent at bottom, stands 10,38816, which is the log. tangent required.

337. But when a logarithm sine or tangent is proposed, to find the deg. and minutes belonging to it, then,

Seek in the table, among the proper columns, for the nearest logarithm to the given one ; and the corresponding degrees and minutes will be found ; observing to reckon them from the top or bottom, according as the column is titled, wherein the nearest logarithm to the given one is found.

338. It may sometimes happen that a log. sine or log. tang. may be wanted to degrees, minutes, and parts of minutes ; which may be thus found.

Take the difference between the logs. of the degrees and minutes next less, and those next greater, than the given number.

Then for $\frac{1}{4}$, take a quarter of this difference ; for $\frac{1}{3}$, take a third ; for $\frac{1}{2}$, take a half ; for $\frac{2}{3}$, take two thirds ; for $\frac{3}{4}$, take three quarters &c.

Add the parts taken of this difference to the right hand figures of the log. belonging to the deg. and min. next less, and the sum will be the log. to the deg. min. and parts proposed.

EXAMPLE I. *Required the log. tang. to 60°. 56 $\frac{1}{2}$ '.*

Log. tan. 60°. 57' is	10,25535
Log. tan. 60 56 is	10,25506
The diff. is	29
Its half is	14
Add it to tan. 60°. 56'.	10,25506
Gives tan. 60 56 $\frac{1}{2}$	10,25520

EXAMPLE II. *Required the log. sine to 32°. 15 $\frac{3}{4}$ '.*

Log. sine 32°. 16' is	9,72743
Log. sine 32 15 is	9,72723
The diff. is	20
Its three fourths is	15
Add it to sine 32°. 15'.	9,72723
Gives sine 32 15 $\frac{3}{4}$	9,72738

In most cases the work may be done by inspection.

339. And if a given log. sine or log. tangent falls between those in the tables ; then the degrees and minutes answering may be reckoned $\frac{1}{4}$, or $\frac{1}{3}$, or $\frac{1}{2}$ &c. minutes more than those belonging to the nearest less log. in the tables, according as its difference from the given one is $\frac{1}{4}$, or $\frac{1}{3}$, or $\frac{1}{2}$ &c. of the difference between the logarithms next greater and next less than the given log.

SECTION

SECTION III.

Of the Solution of Plane Triangles.

340.

PROBLEM I.

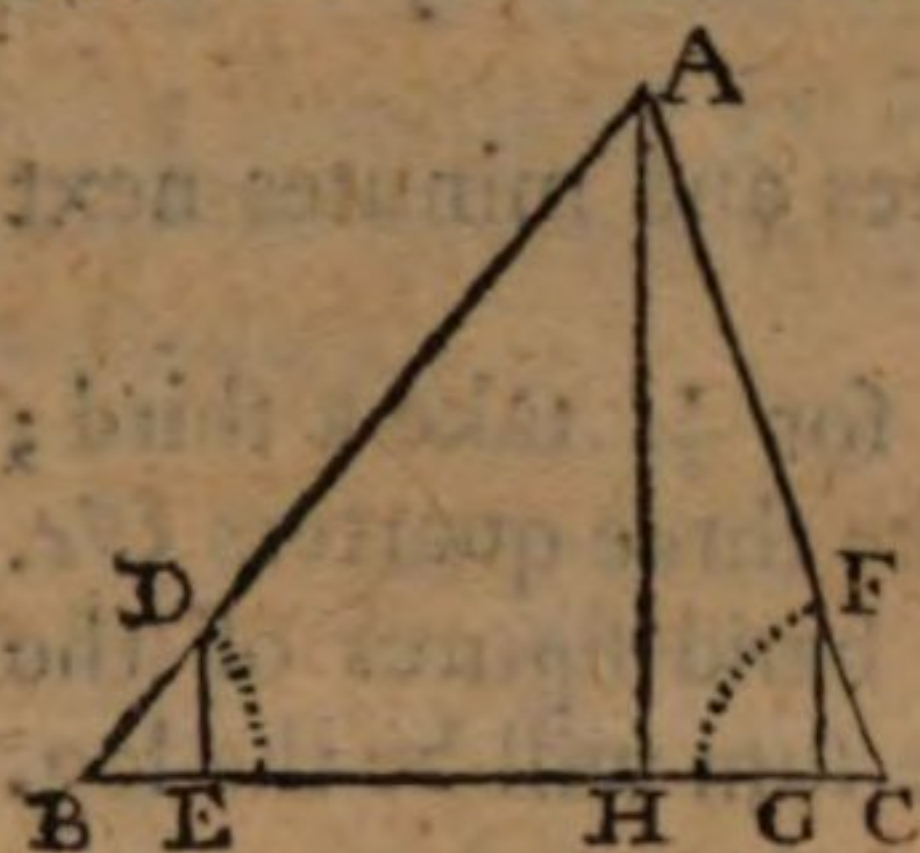
In any plane triangle (ABC) if among the things given there be a side and its opposite angle, to find the rest.

Then say, *As a given side* (AB)
To the sine of its opposite angle; (C)
So is another given side, (AC)
To the sine of its opposite angle (B)

Therefore, to find an angle, begin with a side opposite to a known angle.

Also, *As the sine of a given angle* (B)
To its opposite side; (AC)
So is the sine of another given angle (C)
To its opposite side. (AB)

Therefore, to find a side, begin with an angle opposite to a known side.



DEM. Take $BD = CF =$ radius of the tables.

Draw DE, AH, FG , each perpendicular to BC . (150)

Then DE and FG are the sines of the angles B and C . (298)

Now the triangles BDE, BAH , are similar, and so are the triangles CFG, CAH .

Therefore $BD : DE :: BA : AH$. (250)

And $(CF =) BD : FG :: CA : AH$. (250)

But $(BD \times AH =) DE \times BA = FG \times CA$. (245)

Therefore $DE : CA :: FG : BA$. Or, $s, \angle B : AC :: s, \angle C : BA$. (246)

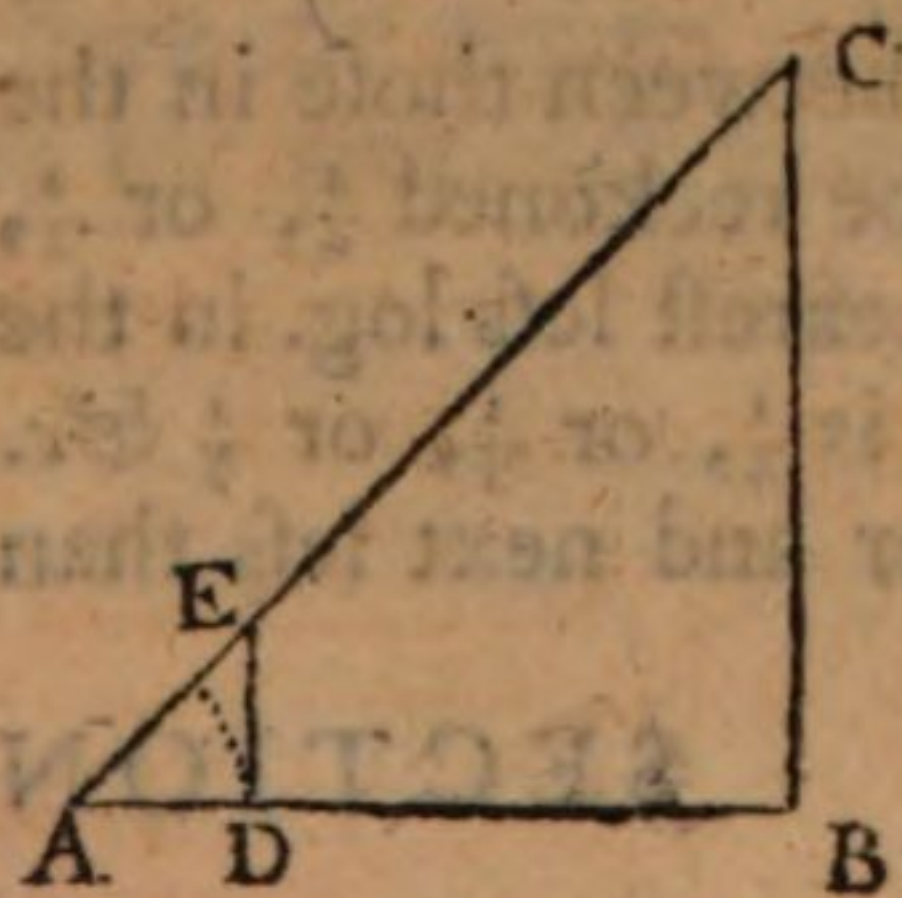
SCHOL. Or, by circumscribing the triangle with a circle, it will readily appear, that the half of each side is the sine of its opposite angle. And halves have the same proportion as the wholes.

341.

PROBLEM II.

In a right angled plane triangle (ABC) if the two sides containing the right angle (B) are known, to find the rest.

Then, *As one of the known sides,* (AB)
To the radius of the tables (or tangent of 45°). (AD)
So is the other known side, (BC)
To the tangent of its opposite angle. (DE)



DEM. Take $AD =$ radius of the tables.

Then DE perpendicular to AD , is the tangent of the angle A . (299)

And the triangles ADE, ABC , are similar.

Therefore $AB : AD :: BC : DE$. (250)

342.

PROBLEM III.

In any two quantities, their half difference added to their half sum, gives the greater.

The half diff. subtracted from the half sum, gives the less.

And the half sum taken from the greater, the remainder will be the half difference of those quantities.

DEM. Let AB be the greater, and BC the less, of two quantities.

Take AD = BC; then BD is their difference.

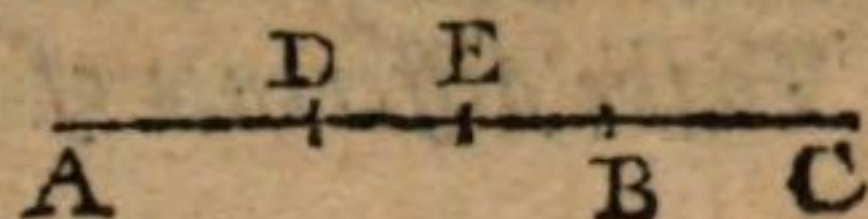
Bisect DB in E; then DE = EB, is the half diff.

And AD + DE = BC + BE (138); therefore AE is the half sum.

Now AE + EB = AB, is the greater

And AE - ED = (AD =) BC, is the less

Also AB - AE = BE, is the half diff.



343.

PROBLEM IV.

In any plane triangle (ABC); if the three things known, be two sides (AC, CB) and their contained angle (C), to find the rest.

Find the sum and difference of the given sides.

Take half the given angle from 90 degrees, and there remains half the sum of the unknown angles. Then say

As the sum of the given sides,

To the difference of those sides;

So is the tangent of half the sum of the unknown angles,

To the tangent of half the difference of those angles,

Add the half difference of the angles to the half sum, and it will give the greater angle = B.

Subtract the half difference of the angles from the half sum, and it will give the lesser angle = A.

$$AC + CB$$

$$AC - CB$$

$$t. \frac{1}{2} B + A$$

$$t. \frac{1}{2} B - A$$

DEM. On C, with the radius CB, describe a circle, cutting AC produced, in E and D, draw EB, and BD; also draw DF parallel to EB.

Then AE = AC + CB, is the sum of the sides.

And AD = AC - CB, is the difference of the sides.

Now $\angle CDB = \angle CBD$.

And $(\angle CDB + \angle CBD =) 2 \angle CDB = \angle CBA + \angle A$.

Therefore $\frac{1}{2} \angle CBA + \angle A = \angle CDB$, is half the sum of the unknown angles.

And BE is the tangent of CDB, to the radius DB.

Also $(\angle CBA - \angle CBD =) \angle DBA = \frac{1}{2} \angle CBA - \frac{1}{2} \angle A$.

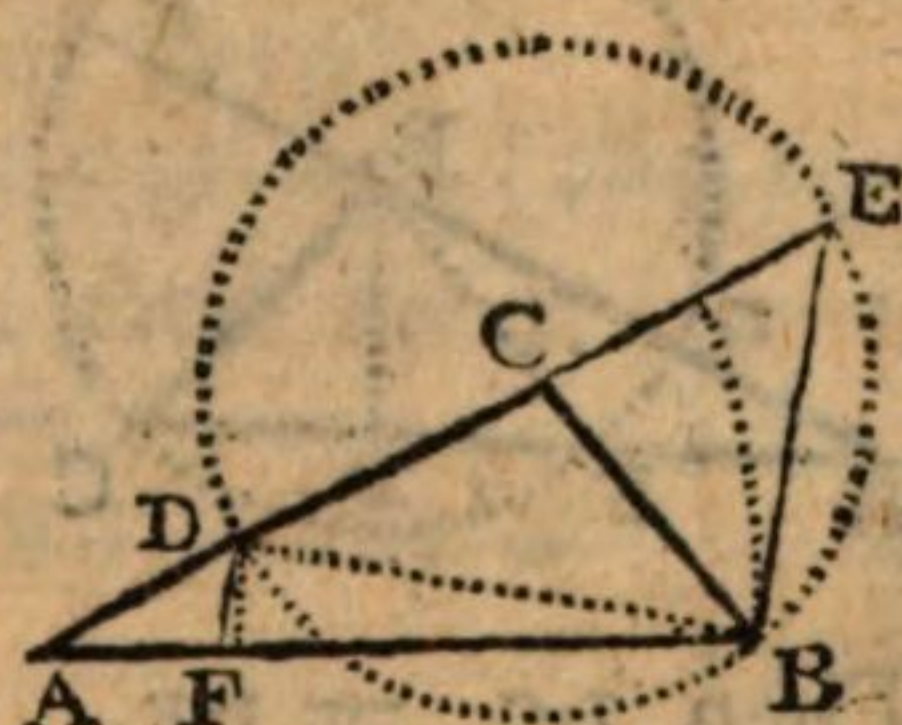
Therefore $\frac{1}{2} \angle CBA - \angle A = \angle DBA$, is half the difference of the unknown angles.

And DF is the tangent of DBA, to the radius DB.

Now the triangles AEB, ADF, are similar, DF being parallel to EB.

Therefore AE : AD :: BE : DF.

Or $AC + CB : AC - CB :: t. \frac{1}{2} \angle CBA + \angle A : t. \frac{1}{2} \angle CBA - \angle A$.



In a plane triangle (ABC), if the three sides are known, and the angles required.

From the greatest angle (B) suppose a line (BD) drawn perpendicular to its opposite side, or base, dividing it into two segments (AD , DC), and the given triangle into two right angled triangles (ADB , CDB): Then say

As the base, or sum of the segments,	AC
Is to the sum of the other two sides;	$AB + BC$
So is the difference of those sides,	$AB - BC$
To the difference of the segments of the base.	$AD - DC$

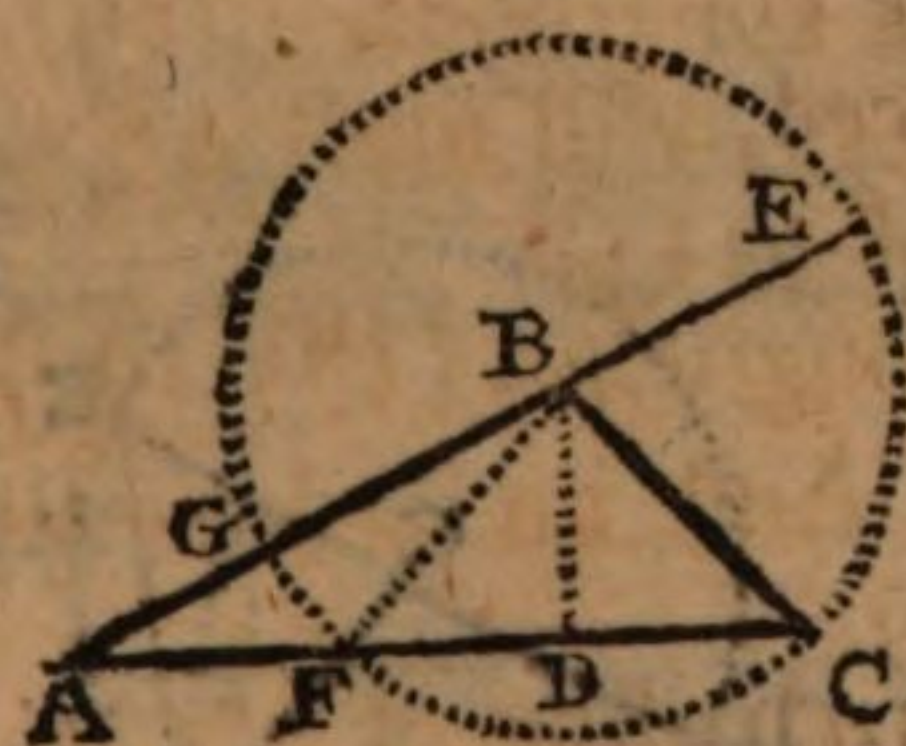
Add half the difference of the segments to half the base, gives the greater segment (AD). (342)

Subtract half the difference of the segments from half the base, gives the lesser segment (DC). (342)

Then, in each of the triangles (ADB , CDB), there will be known two sides, and a right angle opposite to one of them; therefore the angles will be found by Problem I. (340)

When two of the given sides are equal; then a line drawn from the included angle, perpendicular to the other side, bisects the side. (193)

And the angles being found in one of the right angled triangles, will also give the angles of the other.



DEM. Of the foregoing proportion.

In the triangle ABC , the line BD perpendicular to AC , divides AC into the segment AD , DC .

On B with the radius BC , describe a circle GCE , cutting AB , continued, in G , E ; and AC in F ; draw BF .

Then $DC = DF$.

(193)

Now $AC (= AD + DC)$ is the sum of the segments.

And $AF (= AD - FD)$ is the difference of the segments.

Also, $AE (= AB + BC)$ is the sum of the other sides.

And $AG (= AB - BC)$ is the difference of those sides.

But $AC \times AF = AE \times AG$.

(255)

Therefore $AC : AE :: AG : AF$.

(246)

Or $AC : AB + BC :: AB - BC : AD - DC$: Or $= AD - DF$.

345.

PROBLEM VI.

In any plane triangle (ABC), the three sides being known, to find either of the angles.

Put E and F for the sides including the angle sought.

G for the side opposite to that angle.

D for the difference between the sides E and F.

Find half the sum of G and D.

And half the difference of G and D.

Then write these four logarithms under one another, namely

The Arithmetical complement of the logarithm of E.

(88)

The Arithmetical complement of the logarithm of F;

The logarithm of the aforesaid half sum of G and D;

The logarithm of the aforesaid half difference of G and D.

Add them together, take half their sum;

And the degrees and minutes answering, being doubled, will give the sine of the angle sought.

DEM. In the triangle ABC, let A be the angle sought.

Take AH = AB, draw BH; and thro' K, the middle of BH, draw AP, which bisects the Angle A, and is perpendicular to BH (193)

Thro' K draw KL, KQ, parallel to BC, AC; which will bisect HC, BC, in L and I; then KL = IC, KI = LC. (119, 248)

And the difference between AC and AB is HC = D; then KI = $\frac{1}{2}$ D.

From I with the radius IK describe a circle cutting AP, BH, KQ, BC, in P, O, Q, M, N, and join CQ; now IQ = IK = LC = LH; therefore KQ = HC, and CQ = KH, as the triangles CQI, KHL, are congruous. (189).

Therefore CQ parallel to KH (119) being produced, will meet AP at right angles (144), in the point P by the reverse of (213).

Then PQ = KO, as the triangles KQP, QOC, are congruous. (185, 190)

Now BM = (BI + IM = $\frac{1}{2}$ BC + $\frac{1}{2}$ HC =) $\frac{1}{2}$ G + D: And BN = $\frac{1}{2}$ G - D.

Also BO = CP: For BK = (KH =) CQ, and KO = PQ.

Let A r = radius of the tables; then rn (parallel to BH) = sine of $\frac{1}{2}$ $\angle$ A. (298)

Then the triangles Anr, AKB, APC, are similar.

And Ar : rn :: AB : BK; also Ar : rn :: AC : (CP =) BO.

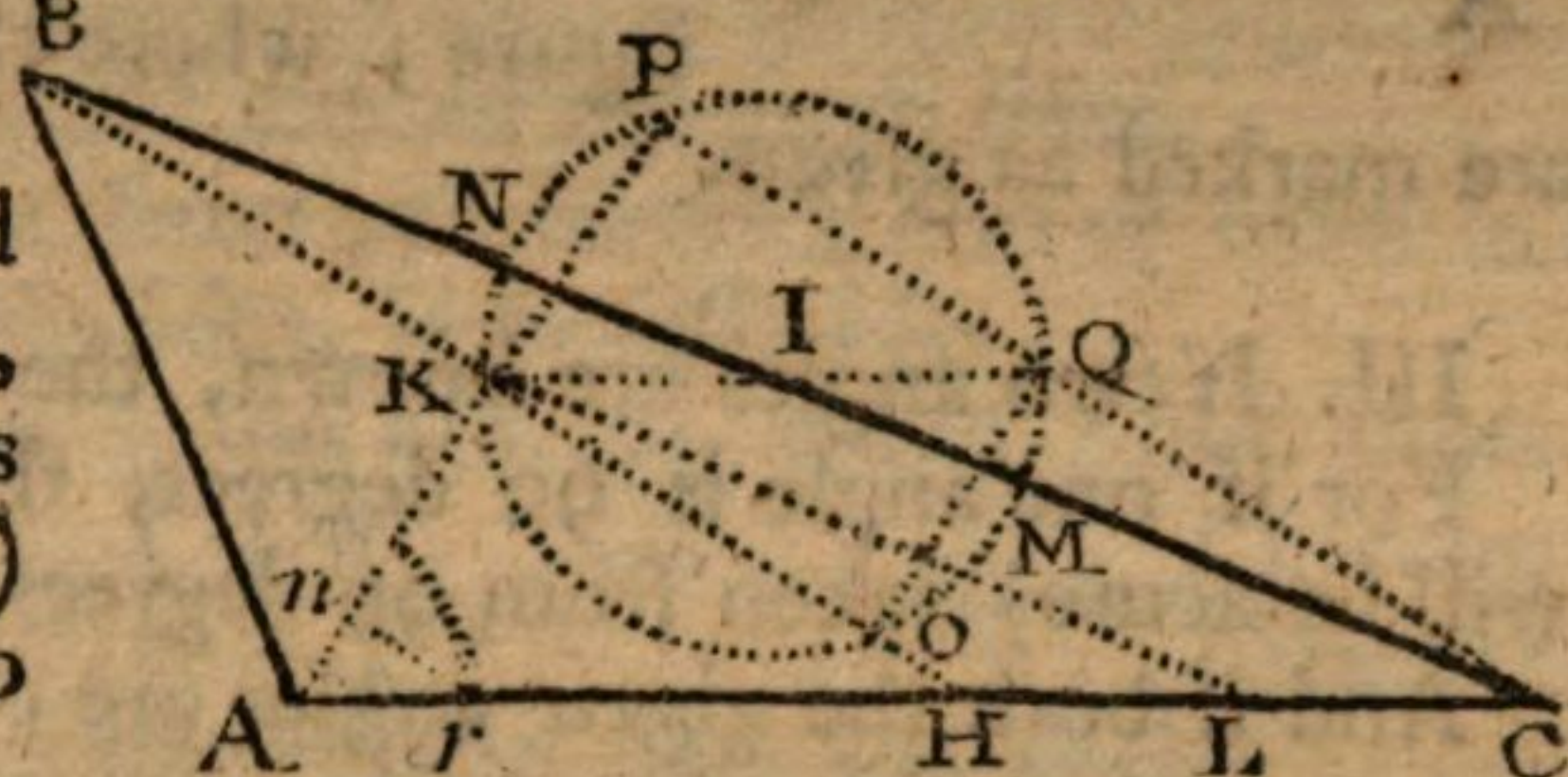
Therefore $\overline{Ar}^2 : \overline{rn}^2 :: AC \times AB : (BK \times BO =) BM \times BN$. (244, 255)

Or (sq. rad. =) $R^2 : \text{sq. sine } \frac{1}{2} \angle A :: AC \times AB : \frac{1}{2} G + D \times \frac{1}{2} G - D$.

Therefore square of the sine $\frac{1}{2} \angle A = \frac{\frac{1}{2} G + D \times \frac{1}{2} G - D}{AC \times AB} \times R^2$. (247)

Therefore sine $\frac{1}{2} \angle A = \sqrt{\frac{\frac{1}{2} G + D \times \frac{1}{2} G - D}{E \times F}}$; because R = I the rad. of the tables.

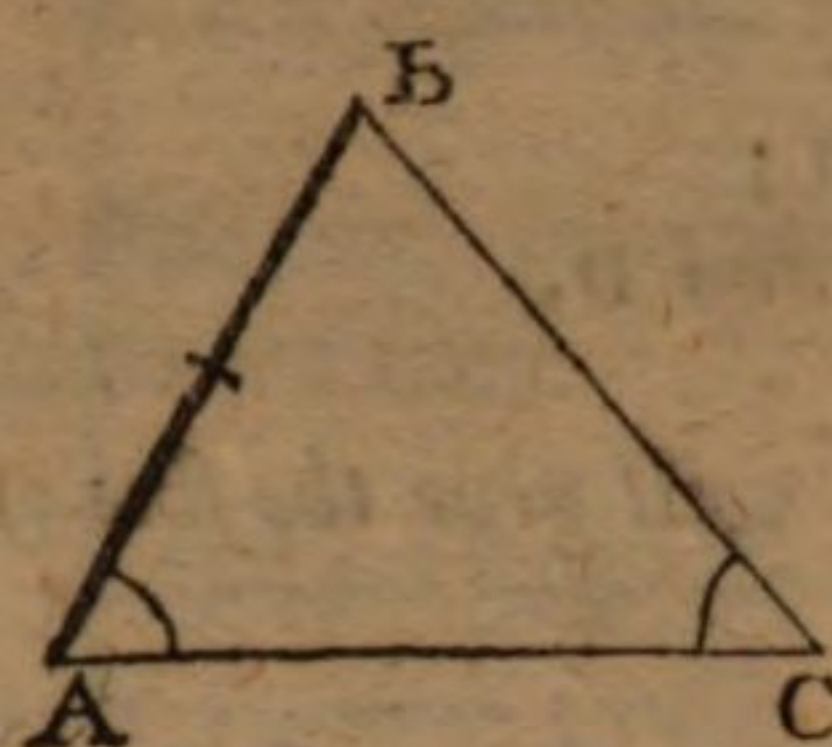
Or



$$\begin{aligned} \text{Or Log. } s, \frac{1}{2} \angle A &= \frac{\text{Log. } \frac{1}{2} G + D + \text{Log. } \frac{1}{2} G - D - \text{Log. } E - \text{Log. } F}{2} \\ \text{Or L. } s, \frac{1}{2} \angle A &= \frac{l. E + l. F + L. \frac{1}{2} G + D + L. \frac{1}{2} G - D}{2} \end{aligned} \left. \begin{array}{l} 85 \\ 86 \\ 91 \end{array} \right\}$$

Where L. stands for logarithm, and l. for Arith. comp. of the logarithm.

346. Every possible case in plane Trigonometry may be readily solved by the preceding Problems, observing the following Precepts.



I. Make a rough draught of the triangle, and put the letters, A, B, C, at the angles.

II. Let such parts of this triangle be marked, as represent the things which are given in the question. Thus, mark a given side with a scratch across it; And a given angle by a little crooked line; as in the figure; where the side AB, and the angles A and C, are marked as given.

III. If two angles are known, the third is always known.

For if one angle is 90 degrees, the other given angle (which (187) will be acute) taken from 90 degrees, leaves the third angle.

And if both the given angles are oblique; their sum taken from 180 degrees, gives the other angle.

IV. Compare the given things together, and thereby determine to which Problem the question proposed belongs.

V. Then according as the Problem directs, perform the preparatory work; and write down, under one another, in four lines, (or more if necessary), the literal stating; expressing each angle by a letter, or by three; each line by two letters; and the sums, or differences, of lines, by proper marks.

VI. Against such terms that are known, write their numeral value as given in the question, or as found in the preparatory work; and against these numbers write their logarithms; those for the lines being found (by 81) in the table of the logarithms of numbers; and those for the angles, found (by 336) in the table of logarithm sines and tangents: Observing that an Arithmetical complement (see 88) is always used in the first term: And that when an angle is greater than 90 degrees, its supplement is used.

VII. Add these logarithms together, and seek the sum (81) in the log. numbers, when a line is wanted; or (337) in the log. sines or tangents, when an angle is wanted. Then the number or degree, answering to a log. the nearest to the said sum, will be the thing required.

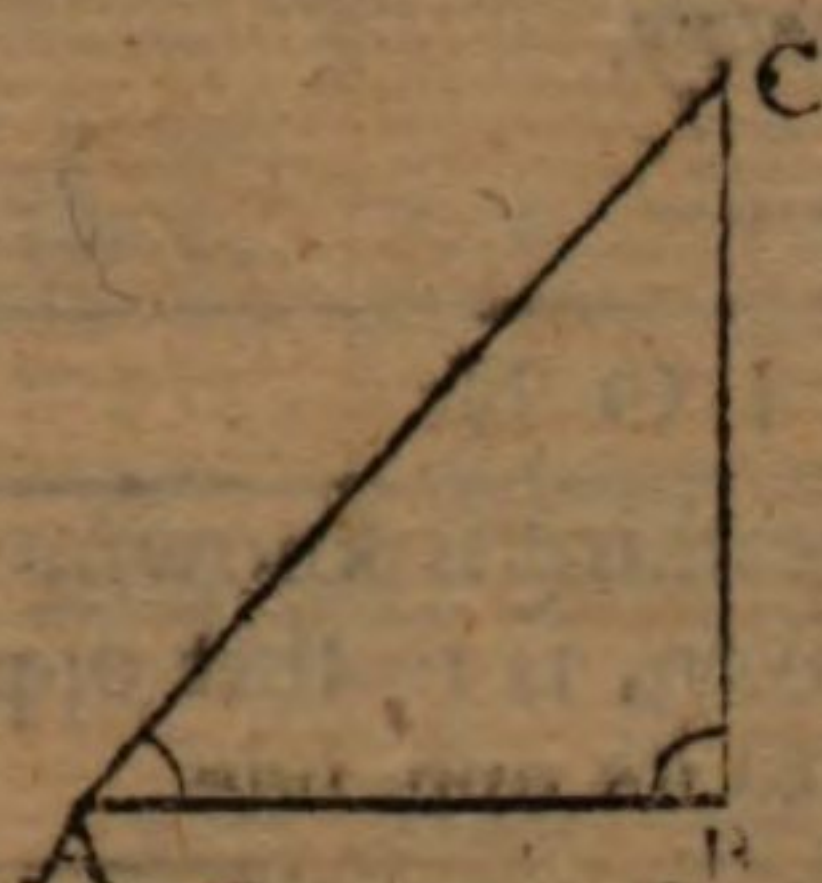
347.

A SYNOPSIS

Of the Rules in Plane Trigonometry.

PROB.	Given	Required	SOLUTION.
	All the angles and one side	either of the other sides	Since two angles are known, the third is known. And, As sin. of $\angle$ opp. to side given, is to that opp. side; So sin. of another angle, to its opp. side.
I. see art. 340	Two sides and an $\angle$ oppof. to one side	The angle opp. to the other giv. side	As one given side, is to the sine of its opp. angle; So is t'other given side, to the sine of its opp. angle. Then two angles being known the third is known And the other side is found as before.
II. art. 341	Two sides and the included right $\angle$	either of the other angles.	As one of the given sides, is to the Radius; So is the other given side, to the tan. of its opp. $\angle$. Then two $\angle$ s being known, the third is known The other side is found by opp. sides and $\angle$ s.
III. art. 343	Two sides and the included oblique angle	The other angles	Find the sum and diff. of the given sides. Take $\frac{1}{2}$ giv. $\angle$ from 90° . leaves $\frac{1}{2}$ sum of other $\angle$ s. Then, As sum sides, is to diff. sides; So tan. $\frac{1}{2}$ sum oth. $\angle$ s, to tan. $\frac{1}{2}$ diff. those $\angle$ s. The $\frac{1}{2}$ sum $\angle$ s $\left\{ \begin{array}{l} + \\ - \end{array} \right\} \frac{1}{2}$ diff. $\angle$ s, gives $\left\{ \begin{array}{l} \text{greater } \angle \\ \text{lesser } \angle \end{array} \right.$ Find the other side by opp. sides and angles.
IV. art. 344	The three sides	All the angles	Draw a line perp. to the greatest side, from the opp. $\angle$, dividing that side into two parts. Then, As the longest side : is to sum other 2 sides; So is the diff. those sides : to the diff. parts of longest Then $\frac{1}{2}$ long. side $\left\{ \begin{array}{l} + \\ - \end{array} \right\} \frac{1}{2}$ diff. pts. gives the $\left\{ \begin{array}{l} \text{great} \\ \text{lesser} \end{array} \right\}$ part. Now the said perp. cuts the triangle into 2 right $\angle$ d. ones. In both, are known the Hyp. a leg. and the right $\angle$. The angles are found by Problem I.
V. art. 345	The three sides	Either Angle	Having chose which angle to find; call the sides including that angle E and F. The side opp. that $\angle$, call G. Put D for the difference between E and F. Find the half sum, and half diff. of G and D. Then write these four logs. under one another Viz. $\left\{ \begin{array}{l} \text{The Ar. Co. log. of E, The Ar. Co. Log. of F,} \\ \text{The Log. of } \frac{1}{2} \text{ sum, And the log. of } \frac{1}{2} \text{ diff.} \end{array} \right.$ Add the four logs. together, take half their sum. Seek it among the log. fines; and the corresponding deg. and min. doubled, is the angle sought.

348. EXAMPLE I. In the plane Triangle ABC.



Given $AB = 195$ Poles

$\angle B = 90^\circ. 00'$

$\angle A = 47. 55$

Required the other parts.

FOR THE LINEAR SOLUTION.

1st. Draw AB equal to 195 poles, taken from a scale of equal parts.

2d. From B , draw BC making with AB an angle of 90° . (175)

3d. From A , draw AC , making with AB an angle of $47^\circ. 55'$; and meeting BC in the point C .

Then is the triangle ABC such whose parts correspond with the things given; and the sides CA , CB , being applied to the scale that AB was taken from, their measures will be found, *viz.* $AC = 291$; and $BC = 216$.

FOR THE NUMERAL SOLUTION, OR COMPUTATION.

Since two angles are known; Therefore

From	$90^\circ. 00' = \angle B$
Take	$47. 55 = \angle A$
Remains	$42. 05 = \angle C$

Now in this triangle, there are known all the angles and one side; therefore among the known things, there is a side and its opposite angle; which belongs to the first problem.

Then to find the side AC , begin with the angle C opposite AB .

As the sine of the $\angle C$
To the opposite side AB
So the sine of the $\angle B$
To the opposite side AC .

Or thus, As s, $\angle C = 42^\circ. 05'$	0,17379 A.C.
To $AB = 195$ po.	2,29003
So s, $\angle B = 90^\circ. 00'$	10,00000
To $AC = 291$ po.	2,46382

And to find the side BC , begin with the angle C opposite AB .

As the sine of the $\angle C$,
To the opposite side AB ;
So the sine of the $\angle A$,
To the opposite side BC .

Or thus, As s, $\angle C = 42^\circ. 05' = 0,17379$ A.C.
To $AB = 195$ po. = 2,29003
So s, $\angle A = 47^\circ. 55' = 9,87050$
To $BC = 216$ po. = 2,33432

So that AC is 291 poles, and BC is 216 poles.

The letters A.C. standing on the right of the first line, signify the arithmetical complement of the log. sine of $42^\circ. 05'$. (See 88)

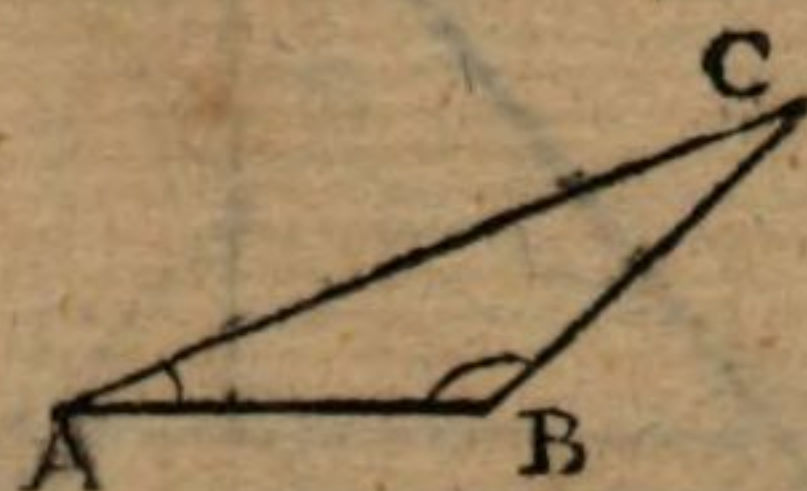
349. EXAMPLE II. In the plane Triangle ABC.

Given $AB = 117$ miles.

$\angle B = 134^\circ 46'$

$\angle A = 22^\circ 37'$

Required the other parts.



FOR THE LINEAR SOLUTION OR CONSTRUCTION.

Make $AB = 117$ equal parts; at A make an angle $= 22^\circ 37'$; and at B make an angle of $134^\circ 46'$; then the lines making with AB those angles will meet in C, and form the triangle proposed.

And the measure of BC will be 117, and of AC 216.

BY COMPUTATION. See art. 340.

Since two angles are known,

Namely $\angle B = 134^\circ 46'$	Now from $180^\circ 00'$	And from, $180^\circ 00'$
$\angle A = 22^\circ 37'$	Take $157^\circ 23'$	Take $134^\circ 46'$
Their sum $= 157^\circ 23'$	Leaves $\angle C = 22^\circ 37'$	The sup ^t . $\angle B = 45^\circ 14'$

Since the angle $C = \angle A$.

Therefore $BC = AB$.

(194)

To find the side AC.

As $s, \angle C = 22^\circ 37'$

To $AB = 117$ M.

So $s, \angle B = 134^\circ 46'$

To $AC = 216$ M.

0,41503 A.C.

2,06819

9,85125 sup.

2,33447

350.

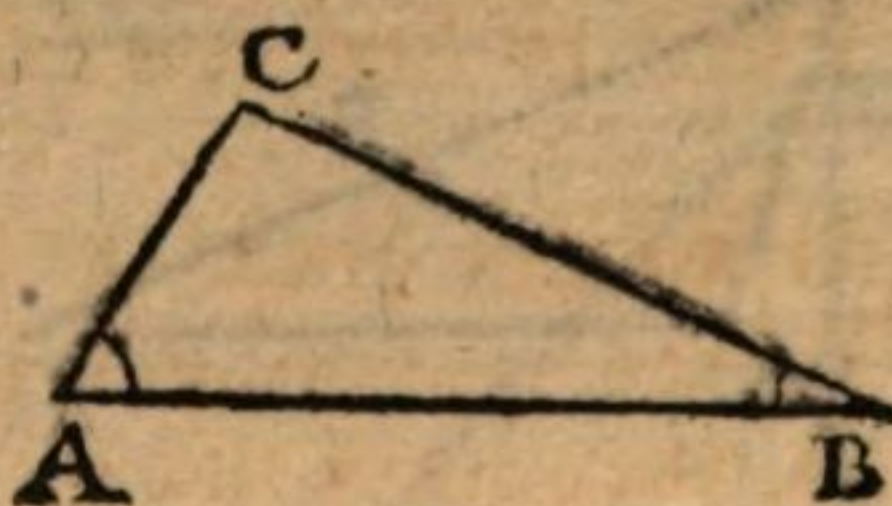
EXAMPLE III. In the plane Triangle ABC.

Given $AB = 408$ yards.

$\angle B = 22^\circ 37'$

$\angle A = 58^\circ 07'$

Required the other parts.



CONSTRUCTION.

Make $AB = 408$ yards, or equal parts; make the angle $A = 58^\circ 07'$; and the $\angle B = 22^\circ 37'$; then the lines forming these angles will meet in C; and the measure of AC is 159 miles, and of BC is 351.

COMPUTATION. See art. 340.

Two angles being known, viz. $\angle A = 58^\circ 07'$	From $180^\circ 00'$
$\angle B = 22^\circ 37'$	Take $80^\circ 44'$
Their sum $= 80^\circ 44'$	Leaves $99^\circ 16' = \angle C$

To find the side AC.

As $s, \angle C = 99^\circ 16'$

To $AB = 408$

So $s, \angle B = 22^\circ 37'$

To $AC = 159$

0,00570 A.C.

2,61066

9,58497

2,20133

To find the side BC.

As $s, \angle C = 99^\circ 16'$

To $AB = 408$

So $s, \angle A = 58^\circ 07'$

To $BC = 351$

0,00570 A.C.

2,61066

9,92897

2,54533

In these operations the supplement of the angle C is used.

351.



351. EXAMPLE IV. In the plane Triangle ABC.

Given $AB=195$ } Furlongs.
 $AC=291$ }

$\angle B=90^\circ 00'$.

Required the rest.

CONSTRUCTION.

Make $AB=195$ equal parts; draw BC , making an angle at $B=90^\circ 00'$: From A with 291 equal parts cut BC in c , and draw AC .

Then the $\angle A$ measured on the scale of chords will be about 48 deg. and $\angle C$ about 42° : Also BC on the equal parts, measures about 216 .

COMPUTATION.

Here being two sides and an angle opposite to one of them, the solution falls under problem the first. See art. 340.

To find the angle c .

As $AC=291$ F. 7,53611 A.C.

To $s, \angle B=90^\circ 00'$ 10,00000

So $AB=195$ F. 2,29003

To $s \angle C=42^\circ 05'$ 9,82614

From $90^\circ 00'$

Take $42^\circ 05' = \angle C$

Leaves $47^\circ 55' = \angle A$.

To find the side BC .

As $s, \angle B=90^\circ 00'$ 10,00000

To $AC=291$ F. 2,46389

So $s, \angle A=47^\circ 55'$ 9,87050

To $BC=216$ F. 2,33439

Here the sine of $90^\circ 00'$ or radius being the first term, its Arith. Comp. being 0, is not taken.

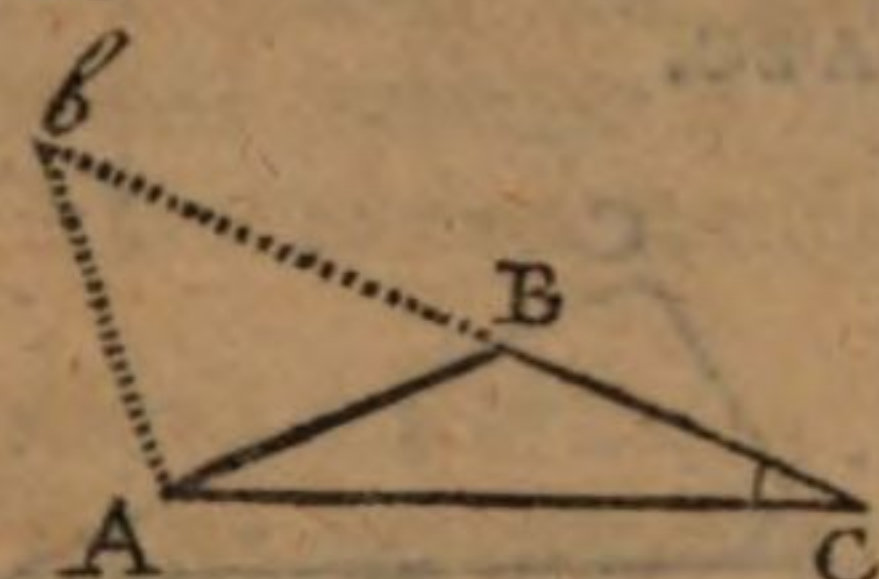
352.

EXAMPLE V. In the plane Triangle ABC

Given $AC=216$ } Yards.
 $AB=117$ }

$\angle C=22^\circ 37'$.

Required the rest.



CONSTRUCTION.

Make $AC=216$ yards; the $\angle C=22^\circ 37'$; and draw CB : Then from A with 117 yards, cut CB in b or in B ; and either of the triangles ACb or ACB will answer the conditions proposed: But the triangle to be used, is generally determined by some circumstances in the question it belongs to. Thus if the angle opposite to AC is to be obtuse, the triangle is ABC .

COMPUTATION.

The solution belongs to problem the first. See art. 340.

To find the angle B .

As $AB=117$ Y. 7,93181

To $s, \angle C=22^\circ 37'$ 9,58497

So $AC=216$ Y. 2,33445

To $s, \angle B=134^\circ 46'$ 9,85123

$\angle C + \angle B=157^\circ 23'$

From $180^\circ 00'$

Take $157^\circ 23' = \angle C + \angle B$

Leaves $22^\circ 37' = \angle A$.

And as the $\angle A = \angle C$

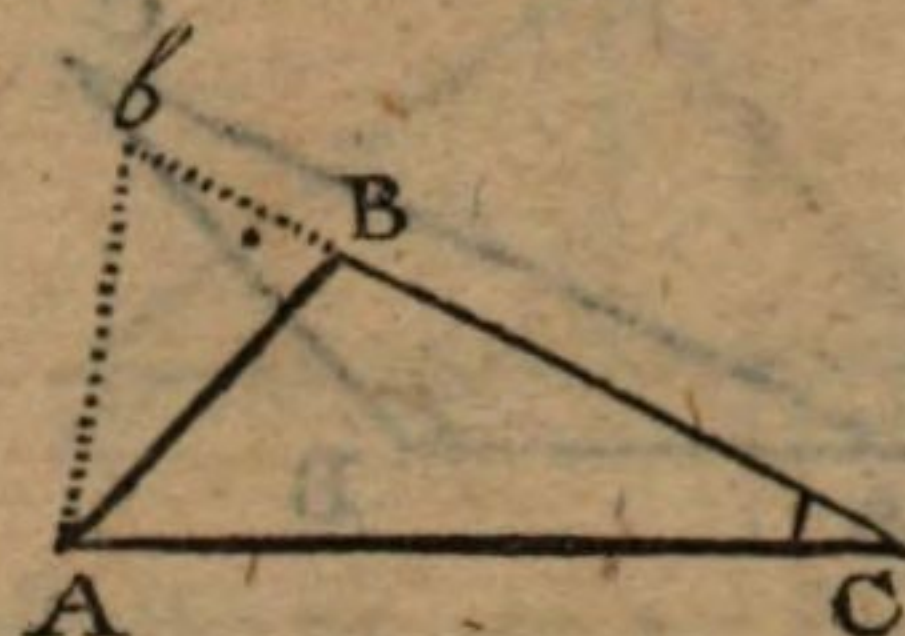
Therefore $BC=AB$. (194)

If the angle required be obtuse, subtract the deg. and min. corresponding to the fourth log. from 180 ; the remainder is the $\angle B$. For the fourth log. gives the $\angle b$, which is the supplement to the angle B . (194, 186)

353.

EXAMPLE VI. In the plane Triangle ABC.

Given $AC=408$ } Fathoms.
 $AB=159$ }
 $\angle C=22^\circ 37'$.
 Required the rest.



CONSTRUCTION.

Make $AC=408$ fathoms; the $\angle C=22^\circ 37'$; and draw cb ; from A with 159 fathoms cut cb in b or in B , and draw Ab or AB :
 Then if the angle opposite to AC is to be acute, the triangle ACb is that which is required; but if the angle is to be obtuse, ACB is the triangle sought.

COMPUTATION. See art. 340.

Here being a side and its opposite angle known, the solution falls under problem the first; the $\angle B$ is to be obtuse.

To find the angle B , obtuse.

As	$AB=159$ F.	7,79860
To	$s, \angle C=22^\circ 37'$	9,58497
So	$AC=408$ F.	2,61066
To	$s, \angle B=99^\circ 19'$	9,99423

To find BC .

As	$s, \angle C=22^\circ 37'$	0,41503
To	$AB=159$ F.	2,20140
So	$s, \angle A=58^\circ 04'$	9,92874
To	$BC=350,9$	2,54517

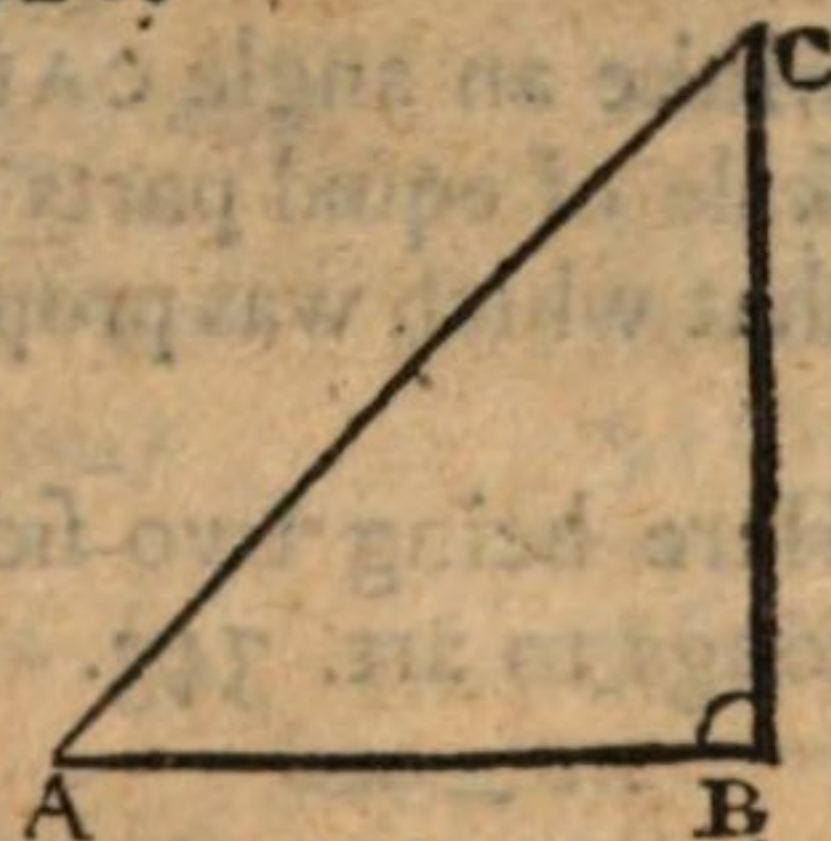
$\angle C + \angle B = 121^\circ 56'$ taken
 From $180^\circ 00'$

Leaves $\angle A = 58^\circ 04'$

354.

EXAMPLE VII. In the plane Triangle ABC.

Given $AB=195$ } Furlongs.
 $BC=216$ }
 $\angle B=90^\circ 00'$.
 Required the rest.



CONSTRUCTION.

Make the angle $ABC=90^\circ$; take $BA=195$ equal parts, and $BC=216$; and draw AC ; then ABC is the triangle proposed; wherein the parts required may be measured by the proper scales.

COMPUTATION. See art. 341.

As two sides and the contained right angle are known, the solution belongs to problem the second.

To find the angle A .

As	$AB=195$ F.	7,70996
To	Radius $=45^\circ 00'$	10,00000
So	$BC=216$ F.	2,33445
To	$t, \angle A=47^\circ 55'$	10,04441

To find AC .

As	$s, \angle A=47^\circ 55'$	0,12950
To	$BC=216$ F.	2,33445
So	$s, \angle B=90^\circ 00'$	10,00000
To	$AC=291$ F.	2,46395

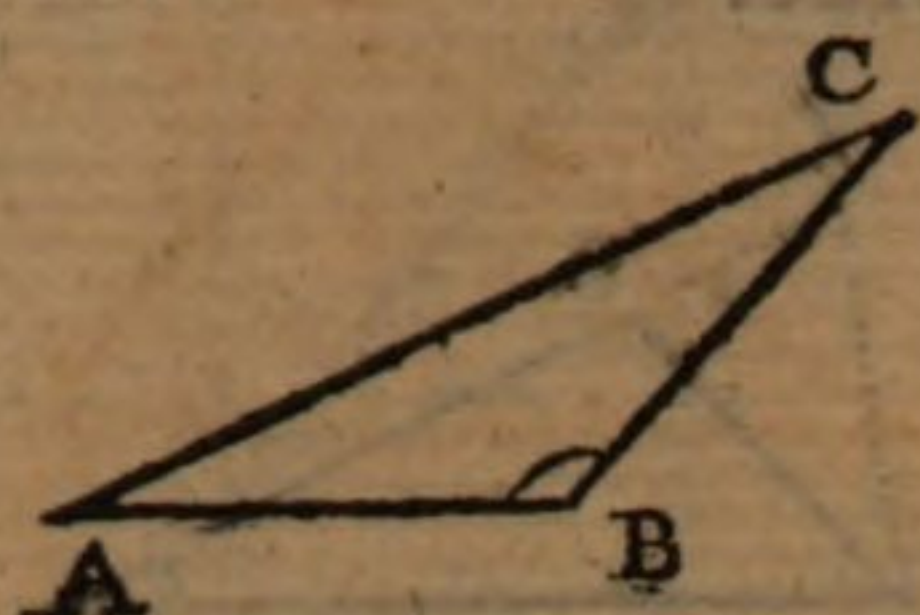
$90^\circ 00'$

$\angle C=42^\circ 05'$

355.

355.

EXAMPLE VIII. In the plane triangle ABC.



Given $AB=117$ } Yards.
 $BC=117$ }
 $\angle B=134^\circ 46'$.
 Required the rest.

CONSTRUCTION.

Make the $\angle ABC=134^\circ 46'$; take BA and BC each equal to 117 equal parts, from the same scale, and draw AC; then is the triangle ABC equal to that proposed; and the parts required measured on their proper scales will give their values.

COMPUTATION. See art. 343.

Now as AB and AC are equal; therefore the angles A and C are also equal.

From $180^\circ 00'$
 Take $134^\circ 46' = \angle B$

Leaves $45^\circ 14' = \angle A + \angle C$.

The half $22^\circ 37' = \angle A = \angle C$.

To find AC.

As $s, \angle A = 22^\circ 37'$ 0,41503

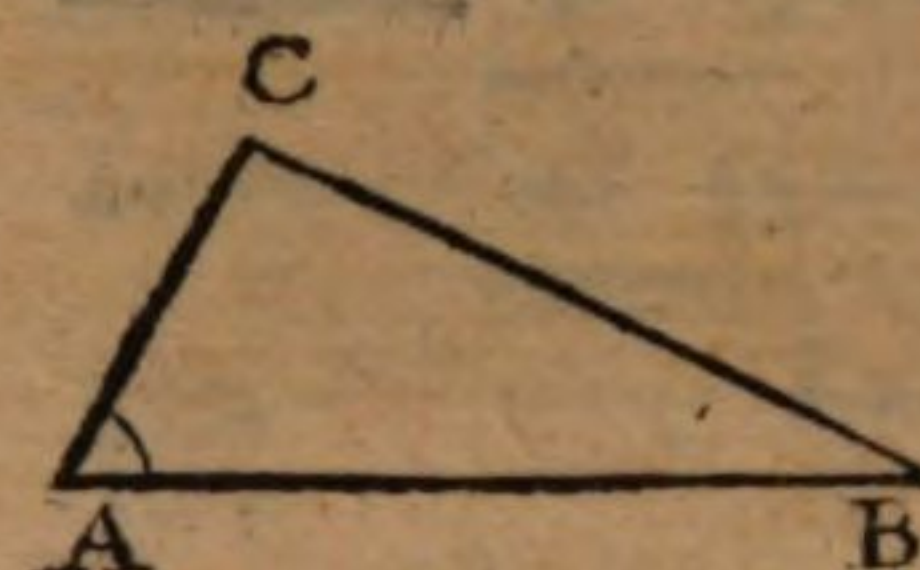
To $BC = 117$ Y. 2,06818

So $s, \angle B = 134^\circ 46'$ 9,85125

To $AC = 216$ Y. 2,33446

356.

EXAMPLE IX. In the plane Triangle ABC.



Given $AB=408$ } Fathoms.
 $AC=159$ }
 $\angle A=58^\circ 07'$.
 Required the rest.

CONSTRUCTION.

Make an angle $CAB=58^\circ 07'$; take $AC=159$, $AB=408$, from the same scale of equal parts; and draw CB; then will the triangle ACB be equal to that which was proposed.

COMPUTATION.

Here being two sides and their contained angle known, the solution belongs to art. 343.

$AB=408$

$AC=159$

$AB+AC=567 = \text{sum of sides}$

$AB-AC=249 = \text{diff. of sides.}$

To find the angles.

As $AB+AC=567$

To $AB-AC=249$

So $t, \frac{1}{2} \angle C + \angle B = 60^\circ 56\frac{1}{2}'$ (See 338) 10,25520

To $t, \frac{1}{2} \angle C - \angle B = 38^\circ 19\frac{1}{2}'$ 9,89782

Then (342) $99^\circ 16' = \angle C$ (195)

And $22^\circ 37' = \angle B$

The half of $58^\circ 07'$ Is $29^\circ 03\frac{1}{2}'$ whichTaken from $90^\circ 00'$

Leaves $60^\circ 56\frac{1}{2}' = \frac{1}{2} \angle C + \frac{1}{2} \angle B$.

To find AC.

As $s, \angle C = 99^\circ 16'$ 0,00570

To $AB=408$ 2,61066

So $s, \angle A = 58^\circ 07'$ 9,92897

To $BC=351$ 2,54533

357.

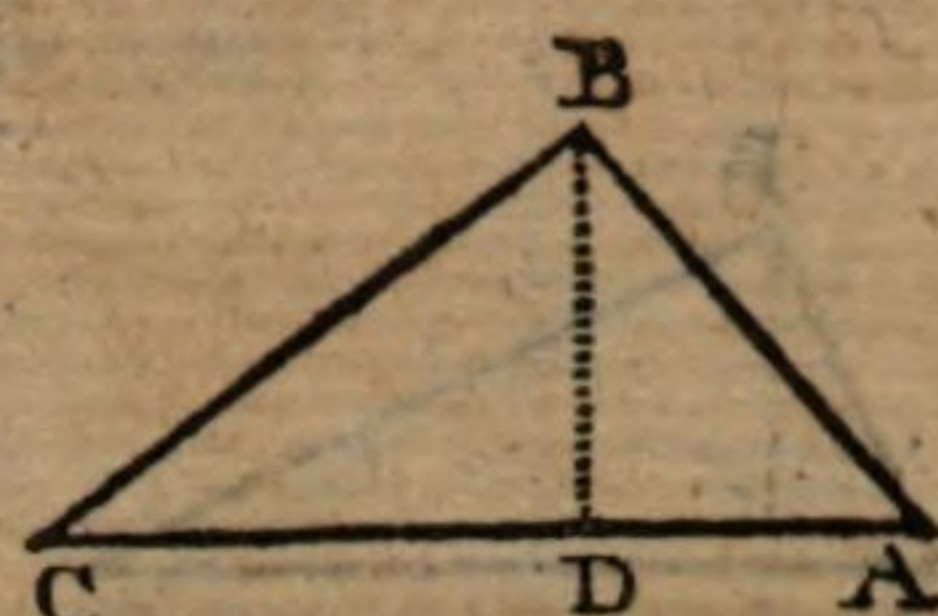
357. EXAMPLE X. In the plane Triangle ABC.

Given $AB=195$

$BC=216$

$AC=291$

Required the angles.



CONSTRUCTION.

Make $CA=291$ equal parts; from C with 216 , describe an arc B ; from A with 195 cut the arc B in B ; draw BC , BA , and the triangle is constructed; then the angles may be measured by the help of a scale of chords.

COMPUTATION.

The three sides being given, the solution falls under either Problem V. or Problem VI. But that the use of these Problems may be sufficiently illustrated, the solutions according to both of them are here annexed.

Solution by Problem V. (344)

From the angle B , draw BD perpendicular to CA , which will be divided into the segments CD , DA , whose sum AC is known.

Now $BC=216$

And $AB=195$

$BC+AB=411$ = sum of sides

$BC-AB=21$ = diff. of the sides

Now the half of 291 is $145,5$
And the half of $29,66$ is $14,83$

Therefore (342) the sum $160,33=CD$; or $CD=160,3$

the diff.

$130,67=AD$; or $AD=130,7$

Then in the triangle CDB .

As $BC=216$ $7,66555$

To $s, \angle CDB=90^\circ 00'$ $10,00000$

So $CD=160,3$ $2,20493$

To $s, \angle CBD=47^\circ 55'$ $9,87048$

Wh. taken from $90^\circ 00'$

Leaves $\angle C=42^\circ 05'$

To find the diff. of the segments.

As $AC=291$ $7,53611$

To $BC+AB=411$ $2,61384$

So $BC-AB=21$ $1,32222$

To $CD-AD=29,66$ $1,47217$

And in the triangle ADB .

As $AB=195$ $7,70996$

To $s, \angle ADB=90^\circ 00'$ $10,00000$

So $AD=130,7$ $2,11628$

To $s, \angle ABD=42^\circ 05'$ $9,82624$

Wh. taken from $90^\circ 00'$

Leaves $\angle A=47^\circ 55'$ & $\angle B=90^\circ 00'$

Solution by Problem VI. (345)

To find the angle c .

Put $E=291=AC$

$F=216=BC$

$G=195=AB$

$D=75=E-F$

$2) 270 (135=\frac{1}{2} G+D$

$2) 120 (60=\frac{1}{2} G-D$

Then To Ar. Co. log. $E=291$ $7,53611$

Add. Ar. Co. log. $F=216$ $7,66555$

And the log. $\frac{1}{2} G+D=135$ $2,13033$

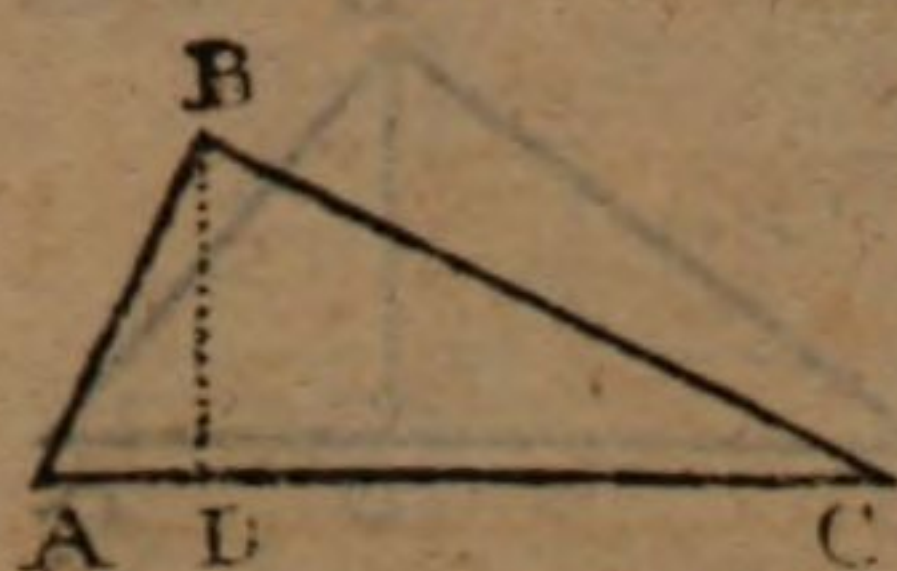
Also the log. $\frac{1}{2} G-D=60$ $1,77815$

The half of this sum $2) 19,11014$

Is the log. sine of $21^\circ 02' \frac{1}{2}$ (339) $9,55507$

Which doubled, gives $42^\circ 05'=\angle c$.

The angle c being found, the other angles may be found by Prob. I.



358. EXAMPLE XI. In the plane Triangle ABC.

Given $AC=408$ $BC=351$ $AB=159$

Required the angles.

CONSTRUCTION.

The construction and mensuration is performed as in the last Ex.

COMPUTATION BY PROB. V. art. 344.

From the $\angle B$ draw the perpendicular BD ; and find the segments AD , DC ; which may be done without logarithms.Thus $BC=351$ Then (46) As $408 : 510 :: 192 : 240 = DC - DA$.
 $AB=159$ For $192 \times 510 = 97920$; which divided by 408 gives 240 . $BC + AB = 510$ Now half of $408 = 204$; and half of 240 is 120 . $BC - AB = 192$ Then $204 + 120 = 324 = DC$; and $204 - 120 = 84 = DA$.In the triangle ADB .

As	$AB = 159$	7,79860
To s, $\angle D$	$= 90^\circ 00'$	10,00000
So	$AD = 84$	1,92428

To s, $\angle ABD$	$= 31^\circ 53'$	9,72288
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And $\angle A = 58^\circ 07'$ In the triangle BDC .

As	$BC = 351$	7,45469
To s, $\angle D$	$= 90^\circ 00'$	10,00000
So	$DC = 324$	2,51054

To s, $\angle CBD$	$= 67^\circ 23'$	9,96523
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And $\angle C = 22^\circ 37'$ Then $\angle ABD + \angle CBD = \angle ABC = 99^\circ 16'$.

COMPUTATION BY PROB. VI. art. 345.

To find the angle c .Put $E = 408 = AC$ $F = 351 = BC$ $G = 159 = AB$ $D = 57 = E - F$ $2) 216 (108 = \frac{1}{2}G + D$ $2) 102 (51 = \frac{1}{2}G - D$ Then To Ar. Co. log. $E = 408$ 7,38934Add. Ar. Co. log. $F = 351$ 7,45469And the log. $\frac{1}{2}G = 108$ 2,03342Also the log. $\frac{1}{2}G - D = 51$ 1,70757

The half of this sum 2) 18,58502

Is the log. sine of $11^\circ 18\frac{1}{2}'$ 9,29251Which doubled, is $22^\circ 37' = \angle c$.Now the angle c being known, the other angles may be found by Prob. I. But for a farther illustration of Prob. VI. the work for another angle is here repeated.To find the angle B .Put $E = 351 = BC$ $F = 159 = AB$ $G = 408 = AC$ $D = 192 = E - F$ $2) 600 (300 = \frac{1}{2}G + D$ $2) 216 (108 = \frac{1}{2}G - D$ Then To Ar. Co. log. $E = 351$ 7,45469Add Ar. Co. log. $F = 159$ 7,79860And the log. $\frac{1}{2}G + D = 300$ 2,47712Also the log. $\frac{1}{2}G - D = 108$ 2,03342

The half of this sum 2) 19,76383

Is the log. sine of $49^\circ 38'$ 9,88191Which doubled, is $99^\circ 16' = \angle B$.

359.

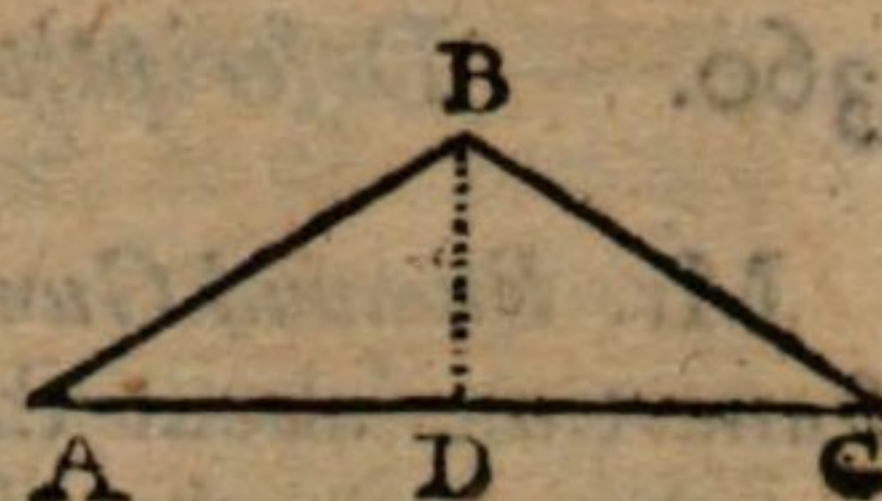
EXAMPLE XII. *In the plane Triangle ABC.*

Given $AB=117$

$BC=117$

$AC=216$

Required the angles.



CONSTRUCTION.

The construction of this triangle, and the measuring of the angles, is performed as in the X. and XI. Examples.

COMPUTATION.

In the triangle ABC, as $AB=BC$; therefore the angles A and C are equal (194); and the perpendicular BD bisects the side AC; so that the right angled triangles ADB, CDB, are congruous; consequently, the angles being found in one triangle, will give those of the other.

Now in the triangle ADB, the side $AB=117$; the side $AD=\frac{1}{2}AC$, is 108; and the $\angle D$ is $90^\circ 00'$: Here being a side and its opposite angle the solution belongs to Prob. I.

To find the angle ABD:

As	$AB=117$	7,93181
To s, $\angle D=90^\circ 00'$		10,00000
So	$AD=108$	2,03342
To s, $\angle ABD=67^\circ 23'$		9,96523

Wh. taken from 90 00

Leaves 22 37 $=\angle A=\angle C.$

And $67^\circ 23'$ doubled

Gives 134 46 $=\angle ABC.$

A like process is to be used in every triangle, wherein are two equal sides.

In the foregoing examples are contained all the variety that can happen in the solutions of plane triangles, considered only with regard to their sides and angles: But besides the methods shewn of resolving such triangles by construction and computation; there is another way to find these solutions, called Instrumental; and this is of two kinds, viz. either by a ruler called a Sector, or by one called the Gunter's scale: The method by the sector, the curious reader may see in many books, particularly in a treatise on Mathematical Instruments published in the year 1747: But the other being in great use at sea, it will be proper in this place to treat of it.

SECTION IV.

360. *Description and Construction of the Gunter's Scale.*

Mr. *Edmund Gunter*, Professor of Astronomy at *Gresham College*, did some time about the year 1624, apply to a flat Ruler the Logarithms of numbers; this he effected, by taking from a scale of equal parts the lengths expressed by the figures in those logarithms, and transferring them to a line or scale drawn on such a ruler; and this is the line, which from his name, is called the *Gunter's Line*: He also, in like manner, constructed lines containing the logarithms of the sines and tangents; and since his time there have been contrived other logarithmic scales adapted to various purposes.

The Gunter's scale is a ruler commonly two feet long; having on one of its flat sides several lines or logarithmic scales; and the other side various other scales; which, to distinguish them from the former, may be called natural scales.

While the reader is perusing what follows, it is proper he should have a Gunter's scale before him.

361. *Of the natural Scales.*

The half of one side is filled with different scales of equal parts, for the convenience of constructing a larger, or smaller figure: The other half contains scales of Rhumbs, marked Ru; Chords, marked Ch; Sines, marked Sin; Tangents, marked Tan; Secants, marked Sec; Semitangents, denoted by S.T. and Longitude, distinguished by M.L. The descriptions and uses of these scales will be considered hereafter, in the places where they will be wanted.

362. *Of the Logarithmic Scales.*

On the other side of the scale are the following lines;

I. A line marked s.R. (sine rhumbs), which contain the logarithm sines of the degrees to each point and quarter point of the compass.

II. A line signed t.R. (tang. rhumbs), whose divisions correspond to the logarithm tangents of the said points and quarters.

III. A line marked Num. (numbers), wherein the logarithms of numbers are laid down.

IV. A line marked sin. containing the log. sines.

V. A line of log. versed sines, marked v.s.

VI. A line of log. tangents, marked Tan.

VII. A meridional line signed Mer.

VIII. A line of equal parts, marked E.P.

363.

I. Of the Line of Numbers.

The whole length of this line or scale, is divided into two equal spaces, or intervals; the beginning, or left hand end of the first, is marked 1; the end of the first interval, and beginning of the second, is also marked 1; and the end of the second interval, or end of the scale, is marked with 10: Both these distances are alike divided, beginning at the left hand ends, by laying down in each, the lengths of the logarithms of the numbers 20, 30, 40, 50, 60, 70, 80, 90; taken from a scale of equal parts, such that 10 of its primary divisions make the length of one interval: And the intermediate divisions are found, by taking the logarithms of like intermediate numbers.

From this construction it is evident, that when the first 1 stands for 1, the second 1 stands for 10, and the end 10 denotes 100;

And if the first 1
is called

$\left\{ \begin{array}{l} 10, \\ 100, \\ \&c. \\ 1\frac{1}{2}, \\ 1\frac{1}{3}, \\ \&c. \end{array} \right.$

the 2d. 1 stands
for

$\left\{ \begin{array}{l} 100, \\ 1000, \\ \&c. \\ 1, \\ 1\frac{1}{2}, \\ \&c. \end{array} \right.$

And the 10 at the
end stands for

$\left\{ \begin{array}{l} 1000; \\ 10000; \\ \&c. \\ 10; \\ 1; \\ \&c. \end{array} \right.$

And the primary and intermediate divisions in each interval, must be estimated according to the values set on their extremities, viz. at the beginning, middle, and end of the scale.

Now the examples most proper to be worked by this scale, are such wherein the numbers concerned do not exceed 1000; and then the first 1 stands for 10, the middle 1 for 100, and the 10 at the end for 1000: The primary divisions in the first interval, viz. 2, 3, 4, 5, 6, 7, 8, 9, stand for 20, 30, 40, 50, 60, 70, 80, 90, and the intermediate divisions stand for units. In the second interval, the primary divisions signed 2, 3, 4, 5, 6, 7, 8, 9, stand for 200, 300, 400, 500, 600, 700, 800, 900; each of these divisions are also divided into ten parts, which represent the intermediate tens. Between 100 and 200, the divisions for tens are each subdivided into five parts; so that these lesser divisions stand for two units. The tens between 200 and 500, are divided into two parts, each standing for five units: The units between the tens from 500 to 1000 are to be estimated by the eye; which by a little practice is readily done.

From this description it will be easy to find the division representing a given number not exceeding 1000: Thus the number 62, is the second small division from the 6, between the 6 and 7 in the first interval: The number 435 is thus reckoned; from the 4 in the second interval, count towards the 5 on the right, three of the larger divisions, and one of the smaller; and that will be the division expressing 435. And the like of other numbers.

364.

II. *For the Line of Sines.*

This scale terminates at 90 degrees, just against the 10 at the end of the line of numbers; and from this termination the degrees are laid backwards, or from thence towards the left: Now seeking in a table of logarithm sines, for the numbers expressing their arithmetic complements, without the index, take those numbers from the scale of equal parts the logs. of the numbers were taken from, and apply them to the scale of sines from 90°, and they will give the several divisions of this scale.

Thus the arith. comp. of the log. sines (or the co-secants) abating the index, of 10°, 20°, 30°, 40°, &c. are the numbers 76033, 46595, 30103, 19193, &c. then the equal parts to these numbers, laid from 90°, will give the divisions for 10°, 20°, 30°, 40°, &c. and the like for the intermediate degrees.

Proceeding in this manner, the arith. comp. of the sine of 5° 45' will be about equal to 10 of the primary divisions of the scale of equal parts, or to one interval in the log. scale; so that a decrease of the index by unity, answers to one interval; then a decrease of the index by 2 answers to 2 intervals, or the whole length of the log. scale; and this happens about the sine of 35 min. and the divisions answering to the sine of a little above 3 min. viz. 3' 26" will be equal to 3 intervals; and the sine of about 26" will be 4 intervals &c. so that the sine of 90° being fixed, the beginning of the scale is vastly distant from it.

'Tis usual to insert the divisions to every 5 minutes, as far as 10 degrees; from 10° to 30°, the small divisions are of 15 minutes each; from 30° to 50°, contains every half degree; from 50° to 70°, are only whole degrees; the rest are easily reckoned.

365.

III. *For the Line of Tangents.*

As the tangent of 45 degrees is equal to the radius, or sine of 90°; therefore 45° on this scale, is terminated directly opposite to 90° on the sines; and the several divisions of this scale of log. tangents are constructed in the same manner as those of the sines, by applying their arith. comp. backwards from 45°, or towards the left hand.

The degrees above 45, are to be counted backwards on the scale: Thus the division at 40, represents both 40° and 50°; the division 30, serves for 30° and 60°; and the like of the other divisions, and their intermediates.

366.

IV. *For the Line of Versed Sines.*

This line begins at the termination of the numbers, sines and tangents: But as the numbers on those lines descend from the right to the left, so these ascend in the same direction: Now having a table of logarithmic versed sines to 180 degrees, let each log. versed sine be subtracted from that of 180 degrees; then the remainders being successively taken from the said scale of equal parts, and laid on the ruler backwards from the common termination, the several divisions of this scale will be obtained.

366.

The numbers for each 10 deg. are in the following table.

Deg.	Numb.	D.	Numb.	D.	Numb.	Deg.	Numb.	Deg.	Numb.	Deg.	Numb.
10	0,0033	40	0,0540	70	0,1733	100	0,3839	130	0,7481	160	1,5207
20	0,0133	50	0,0854	80	0,2315	110	0,4828	140	0,9319	170	2,2194
30	0,0301	60	0,1249	90	0,3010	120	0,6021	150	1,1740	180	10,3010

The other scales will be described in their proper places.

367. *Demonstration of the foregoing constructions.*

That of the log. numbers, is evident from the nature of logarithms.

For the Sines and Tangents.

Now co-sine : rad. :: rad. : secant (329). Then cos. x secant = 1
 sine : rad. :: rad. : co-sec. (330). sine x co-sec. = 1
 tang. : rad. :: rad. : co-tan. (331). tan. x co-tan. = 1 } 245

The radius of the tables being supposed equal to 1.

Hence it is evident, that in either case, one of the quantities will be equal to the quotient of unity divided by the other.

But division is performed, by subtraction with logarithms.

And to subtract a log. is the same as to add its arith. comp.

Consequently the logarithmic co-sine and secant of the same degrees, are the arithmetical complements of one another.

And so are the logarithmic sines and co-secants: Also the logarithmic tangents and co-tangents are the arith. comp^s. of one another.

368. Now as the arith. comp. of any number, is what that number wants of unity in the next superior place.

Therefore every natural sine and its arith. comp. together make the radius.

And the sines begin at one end of a radius, and end in 90° at the other end.

Therefore in a scale of sines, the arith. comp. of any sine, or its co-secant, laid backwards from 90° gives the division for that sine. And the like must happen in a scale of log. sines.

369. Also, as the logarithmic tangents and co-tangents are the arith. comp. of one another. Therefore in a scale of log. tangents, the divisions to the degrees both under and above 45, are equally distant from the division of 45°.

Consequently the divisions serving to the degrees under 45, will serve, by reckoning backwards, for those above 45.

370. *For the Versed Sines.*

Although the numbers in the line of versed sines ascend from right to left, yet they are only the supplements of the real versed sines, whose order in numbering is the same as the sines, that is from left to right: But as the beginning of the versed sines falls without the ruler, therefore 'tis most convenient to lay down the divisions from the point where the versed sines terminate at 180 degrees, that is against 90° on the sines.

Now 'tis evident that the divisions laid off from this termination must be the differences between the log. versed sines of the several degrees &c. and that of 180 degrees.

SECTION V.

371. *The use of the Gunter's Scale in Plane Trigonometry.*

When a Trigonometrical question is to be solved by the Gunter's scale, it must first be stated by the precepts to that problem under which the question falls, whether it be by opposite sides and angles, or by two sides and their included angle, or by the three sides.

372. In all proportions wrought by the Gunter's scale, when the first and second terms are of the same kind, then

The extent from the first term to the second, will reach from the third term to the fourth.

Or, when the first and third terms are of the same kind

The extent from the first term to the third, will reach from the second term to the fourth.

That is, set one point of the compasses on the division expressing the first term, and extend the other point to the division expressing the second (or third) term; then, without altering the opening of the compasses, set one point on the division representing the third term (or second term), and the other point will fall on the division shewing the fourth term or answer.

In working by these directions, it is proper to observe.

273. First. The extent from one side to another side, is to be taken from the scale of Numbers; and the extent from one angle to another is to be taken from the scale of sines, in working by opposite sides and angles; or from the scale of tangents, in working by two sides and the included angle.

Secondly. When the extent from the first term to the second (or third) is decreasing, or from the right to the left, then the extent from the third term (or second) must be also decreasing; that is, applied from the right towards the left: And the like caution is necessary when the extent is from the left towards the right.

The precepts being carefully attended to, what follows will be readily understood.

374. In EXAMPLE I. See article 348.

As $s, \angle C : AB :: s, \angle B : AC$. Or $s, 42^\circ 05' : 195 :: s, 90^\circ 00' : Q$, where Q stands for the number sought.

Now the extent from $42^\circ 05'$ to $90^\circ 00'$, taken on the scale of sines, and applied to the scale of numbers, will reach from 195 to 291. See art. 364.

Also. As $s, \angle C : AB :: s, \angle A : BC$. Or $s, 42^\circ 05' : 195 :: s, 47^\circ 55' : Q$.

Then the extent from $42^\circ 05'$ to $47^\circ 55'$ on the sines, being applied to the numbers, will reach from 195 to 216. See art. 363.

In each of these operations, the first extent was from the left to the right, or increasing; therefore the second extent must be from left to the right.

375. In EXAMPLE IV. See art. 351.

As $AC : s, \angle B :: AB : s, \angle C$. Or $291 : s, 90^\circ 00' :: 195 : Q$.

Here the extent from 291 to 195, taken on the numbers, and applied to the sines, will reach from $90^\circ 00'$ to $42^\circ 05'$.

The first extent being from the right towards the left, or decreasing; therefore the second extent must be also from the right to the left.

In EXAMPLE VII. See art. 354.

As $AB : \text{Rad.} :: BC : t, \angle A$. Or $195 : t, 45^\circ 00' :: 216 : Q$.

Then the extent from 195 to 216 on the numbers, will reach from $45^\circ 00'$ to $47^\circ 55'$ on the tangents.

Here the first extent being from left to right, or increasing; therefore the second extent must also be increasing: Now on the tangents, this increase above 45° does not proceed from left to right, but from right to left, the same way that the decrease proceeds (365); consequently the division which the point falls on for the fourth term, must be estimated according as the first extent is increasing or decreasing.

Thus had the proportion been,

As $BC : \text{Rad.} :: AB : t, \angle C$. Or $216 : t, 45^\circ 00' :: 195 : Q$.

Then the extent from 216 to 195 on the numbers, will reach from $45^\circ 00'$ to $42^\circ 05'$, estimated as decreasing.

376. When two sides and the included angle are given, and the tangent of half the difference of the unknown angles is required.

Then, on the line of numbers take the extent from the sum of the given sides to their difference; and on the line of tangents apply this extent from 45° downwards, or to the left; let the point of the compasses rest where it falls, and bring the other point (from 45°) to the division answering to the half sum of the unknown angles; then this extent applied from 45° downwards, will give the half difference of the unknown angles: Whence the angles may be found. (342)

Q

In

In EXAMPLE IX. See art. 356.

$$\begin{array}{l} \text{As } AB + AC : AB - AC :: t, \frac{1}{2}\angle C + \angle B : t, \frac{1}{2}\angle C - \angle B. \\ \text{Or } 567 : 249 :: t, 60^\circ 56' : Q. \end{array}$$

Now the extent from 567 to 249 on the numbers, being applied to the tangent, will reach from 45° to about $23^\circ 40'$: Let one point of the compasses rest on this division, and bring the other to $60^\circ 56'$; then this extent will reach from 45° to $38^\circ 19'$ the half difference sought.

And this method will always give the half difference whether the half sum of the angles is greater or less than 45° .

377. But when the half sum and half diff. are greater than 45° . Then the extent from the sum of the sides to their diff. on the scale of numbers, will (on the tangents) reach from the half sum of the angles to their half diff. reckoning from left to right.

And when the half sum and half diff. are both less than 45° ; then the extent from the sum of the sides to their diff. taken from the numbers and applied to the tangents, will reach from the half sum of the angles downwards to their half diff.

378. When the three sides are given to find an angle, and a perpendicular is drawn from an angle to its opposite side. See Ex. X. art. 357.

$$\begin{array}{l} \text{As } AC : BC + AB :: BC - AB : CD - AD. \\ \text{Or } 291 : 411 :: 21 : Q. \end{array}$$

Now the extent from 291 to 411 on the scale of numbers, will reach from 21 to 29,6 also on the numbers.

Then the extent for the angles is performed in the same manner as shewn in Ex. I. (373)

379. Or an angle may be found by Problem VI. as follows.

In the scale of numbers, take the extent from the half sum (of G & D) to either of the containing sides (as E); apply this extent from the other containing side (as F), to a fourth term: Let one point of the compasses rest on this fourth term, and extend the other to the half difference (of G & D); then this extent applied to the versed sines, from the beginning, will give the supplement of the angle sought.

In EXAMPLE X. See art. 357.

$$E = 291; F = 216; \text{ half sum} = 135; \text{ half diff.} = 60.$$

Then on the numbers, the extent from 135 to 291, will reach from 216 to 465; let the point rest there, and extend the other to 60; then this extent applied to the versed sines, will reach from the beginning to $137^\circ 56'$; which taken from 180° , leaves $42^\circ 04'$ for the angle sought.

380.

In EXAMPLE XI. See art. 358.

Here $E = 408$; $F = 351$; half sum of G & $D = 108$; half diff. $= 51$.

Then on the numbers, the extent from 108 to 408, will reach from 351 in the second interval, to some point beyond the scale; therefore apply the extent in the first interval, which will reach from 35,1 to 132,6; let one point rest at 132,6 and extend the other to 51: Now as this extent is less than it ought to be by one interval, or half the length of the scale of numbers; therefore the last extent must be applied, on the versed fines, from the point opposite to the middle of the scale of numbers, which is nearly at 143° ; then it will reach from thence to $157^\circ 23'$, which taken from 180° leaves $22^\circ 37'$ for the angle sought.

Most of the writers on Plane Trigonometry treat of right angled, and of oblique angled triangles separately; making seven cases in the former and six cases in the latter: But as every one of these thirteen cases fall under one or other of the foregoing Problems, therefore such distinctions are here avoided, it being conceived that they rather tend to perplex than instruct a learner: Also in the generality of the treatises on this subject 'tis usually shewn how the solutions of right angled triangles are performed by making (as 'tis called) each side radius; that is, by comparing each side of the triangle with the radius of the tables: And altho' these considerations are here omitted, yet the inquisitive reader will find them in the table at article 684.





THE
ELEMENTS
OF
NAVIGATION.
BOOK III.
OF SPHERICS.

SECTION I.
Definitions and Principles.

381. **S**PHERICS is that part of the Mathematics which treats of the position and mensuration of arcs of circles described on the surface of a sphere.

382. A sphere is a solid contained under one uniform round surface, such as would be formed by the revolution of a circle about a diameter thereof, that diameter being immoveable during the motion of the circle.

Thus the circle AEBD revolving about the diameter AB, will generate a sphere, whose surface will be formed by the circumference AEBD. See Plate I.

383. The centre and axis of a sphere are the same as the centre and diameter of the generating circle: And as a circle has an indefinite number of diameters, so a sphere may be considered as having also an indefinite number of axes, round any one of which the sphere may be conceived to be generated.

384. Circles of the sphere, are those circles described on its surface, by the motion of the extremities of such chords in the generating circle as are at right angles to the diameter thereof, or to the axis of the sphere.

Thus by the motion of the circle AEBD about the diameter AB, the extremities of the chords ED, GF, IH, at right angles to AB, will describe circles whose diameters are equal to those chords. Plate I.

385. The Poles of a circle on the sphere, are those points on its surface equally distant from the circumference of that circle.

Thus A and B are the poles of the circles described on the sphere by the ends of the chords ED, GF, IH. Plate I.

386. A great circle of the sphere, is that circle which is equally distant from both its poles.

Thus the circle described by the extremities E, D, of the diameter ED, at right angles to AB, being equally distant from its poles A and B, is called a great circle.

387. Lesser circles of the sphere, or small circles, are those which are unequally distant from both their poles.

Thus the circles whose diameters are FG, HI, having their poles A and B unequally distant from them, are called lesser circles.

388. Parallel circles of the sphere are such whose planes are considered as parallel to the plane of some great circle.

Thus the circles whose diameters are FG, HI, are called parallel circles in respect to the great circle whose diameter is ED.

389. A spheric angle is the inclination of two great circles of the sphere meeting one another; and is measured by an arc of a great circle intercepted between the legs of that angle, at 90 degrees distant from the angular point.

390. A spheric triangle is a figure formed on the surface of a sphere by the mutual intersections of three great circles.

391. The stereographic projection of the sphere, is such a representation of its circles upon the plane of one of them passing thro' the centre, and called the plane of projection, as would appear to an eye placed in one of the poles of that great circle, and thence viewing the circles on the sphere.

392. The place of the Eye is called the projecting point, or lower pole, and the point diametrically opposite is called the remotest, or opposite, or upper pole.

393. The Primitive circle is that great circle which limits or bounds the representation or projection.

394. An Oblique circle is the projection of such a great circle whose plane lies obliquely to the eye.

395. A Right circle is represented by a diameter of the primitive circle, and is the projection of that great circle whose plane passes thro' the eye, or is seen edgewise.

AXIOMS.

396. The diameter of every great circle passes thro' the centre of the sphere; but the diameters of all small circles do not pass thro' the same centre: Also the centre of the sphere is the common centre of all its great circles.

397. Every section of a sphere by a plane, is a circle.

398. A sphere is divided into two equal parts by the plane of every great circle; and into two unequal parts by the plane of every small circle.

399. The pole of every great circle is at 90 degrees distance from it on the surface of the sphere: And no two great circles can have a common pole.

400. The poles of a great circle are the extremities of that diameter, or axis of the sphere which is perpendicular to the plane of that circle.

401. Lines flowing to the projecting point, or place of the eye, from every point in the circumference of a circle which it views, form the convex surface of a Cone.

402. The projection of any point on the sphere, is that point in the plane of projection thro' which the visual ray passes to the eye.

403. A plane passing thro' three points on the surface of a sphere, equally distant from the pole of a great circle, will be parallel to the plane of that circle.

404. The shortest distance between two points on the surface of a sphere, is the arc of a great circle passing thro' those points.

405. If one great circle meets another, the angles on either side are supplements to one another; and every spheric angle is less than 180 degrees.

406. If two circles intersect one another, the opposite angles are equal.

407. Two spheric triangles are congruous, if two sides and their contained angle in one, are equal to two sides and their contained angle in the other each to each: Or if two angles and the contained side in the one, are equal to two angles and their contained side in the other each to each: Or if the three sides in the one, are respectively equal to the three sides in the other.

408. All parallel circles having the same pole, may be conceived to be concentric to the great circle to which they are parallel.

409. All circles on the sphere having the same pole, are cut into similar arcs by great circles passing thro' that pole.

SECTION

S E C T I O N II.

S T E R E O G R A P H I C P R O P O S I T I O N S.

410.

P R O P O S I T I O N I.

Great circles of a sphere mutually cut one another into two equal parts.

DEMONST. Any two great circles have the same common centre. (396)

And their planes intersect in a right line. (283)

Now the centre must lye in their intersection.

Therefore this right line is a diameter common to both.

But every circle is bisected by its diameter.

Therefore the circles mutually bisect one another.

411. COROL. I. Two great circles intersecting one another, twice, the angles at both sections are equal.

For the planes of those circles have the same inclination on either side of their intersection.

412. COROL. II. Two great circles of the sphere will cut each other twice at the distance of 180 degrees, or in opposite points of this sphere.

413.

P R O P. II.

The distance of the poles of two great circles, is equal to the angle formed by the inclination of those circles. Plate I.

DEM. Let AEB, CED, be two great circles of the sphere, their planes passing thro' its centre F; and let a, b , be the poles of the former, and c, d , the poles of the latter.

Then is the arc $Aa = \text{arc } Cc = 90^\circ$. (399)

And the arc ca is common to both.

Therefore the arc AC measuring the inclination cFA of the circles, is equal to the arc ac measuring the distance of the poles.

414. COROL. I. Two great circles are at right angles to one another when they pass thro' each other's poles.

415. COROL. II. The pole of a great circle is 90 degrees distant from it, taken in another great circle, or in an arc thereof, drawn perpendicular to the former circle.

416. COROL. III. Two or more great circles at right angles to another great circle, intersect one another at 90° distant from it, or in the pole of the latter circle. And the like of arcs of great circles.

417. COROL. IV. If several great circles intersect one another in the pole of another great circle; then are the former circles perpendicular to the latter.

In the stereographic projection of the sphere, the representations of all circles, not passing thro' the projecting point, will be circles. Plate I. three figures.

Let $ACEDB$ represent a sphere, cut by a plane RS , passing thro' the centre I , at right angles to the diameter EH , drawn from E the place of the eye.

And let the section of the sphere by the plane RS , be the circle $CFDL$, whose poles are H and E .

Suppose AGB is a circle on the sphere to be projected, whose pole, most remote from the eye, is P : And the visual rays from the circle AGB meeting in E , form the cone $AGBE$, whereof the triangle AEB is a section thro' the vertex E , and diameter of the base AB . (278)

Then will the figure $agbf$, which is the projection of the circle BGA , be a circle.

DEMONSTRATION. Since the $\angle Eab$ is measured by $\frac{1}{2}$ arc $AC + (\frac{1}{2} \text{ arc } ED =) \frac{1}{2} \text{ arc } CE$. (220)

And the $\angle EBA$ is measured by $\frac{1}{2} \text{ arc } AC + \frac{1}{2} \text{ arc } CE$. (211)

Therefore the angle $EBA = \text{angle } Eab$. (141)

And so the triangles EAB , Eba , are similar, the $\angle E$ being common.

Therefore ab cuts the sides EA , EB , of the cone in a subcontrary position to AB ; and consequently the section $afbg$ is a circle. (286)

Now suppose the plane RS to revolve on the line CD , till it coincides with the plane of the circle $ACEB$.

Then 'tis evident that the point L will fall in H , the point F in E , and the circle $CFDL$ will coincide with the circle $CEDH$, which now becomes the primitive circle, where the point F , or E , is the projecting point: Also the projected circle $afbg$ will become the circle $anbk$.

419. COROL. I. Hence the middle of the projected diameter is the centre of the projected circle, whether it be a great circle or a small one.

420. COROL. II. Hence in all circles parallel to the plane of projection, their centres and poles will fall in the centre of the projection.

421. COROL. III. The centres and poles of circles inclined to the plane of projection, fall in that diameter of the primitive circle which is at right angles to the diameter drawn thro' the projecting point; but at different distances from its centre.

422. COROL. IV. All oblique great circles cut the primitive circle in two points diametrically opposite.

423.

PROP. IV.

The projected diameter of any circle subtends an angle at the eye equal to the distance of that circle from its nearest pole, taken on the sphere. And that angle is bisected by a right line joining the eye and that pole. Plate I.

Let the plane RS cut the sphere HREG as in the last.

And let ABC be any oblique great circle, whose diameter AC is projected in ac ; and KOL any small circle parallel to ABC, whose diameter KL is projected in kl .

The distances of those circles from their pole P, being the arcs AHP, KHP, and the angles aEc , kEl , are angles at the eye subtended by their projected diameters ac , kl .

Then is the angle aEc measured by the arc AHP, the angle kEl is measured by the arc KHP; and those angles are bisected by EP.

DEM. For arc PHA = arc PC; and arc PHK = arc PL. (385)

And the $\angle AEC$ is measured by $\frac{1}{2}$ arc APC = arc PHA. (220)

Also the $\angle KEL$ is measured by $\frac{1}{2}$ arc KPL = arc PHK. (220)

Therefore the angles AEC, KEL, are respectively measured by the arcs PHA, PHK.

And 'tis evident those angles are bisected by the line EP.

424. COROL. I. Hence as the line EP projects the pole P in p ; so the same line refers a projected pole to its place on the sphere, in the circumference of the primitive circle.

425. COROL. II. Hence on the primitive circle may be described the representation of any circle whose distance from its pole, and the projected place of that pole are given.

For PA and PC are projected into pa and pc ; and the bisection of ac gives the centre of the circle sought.

426. COROL. III, Hence every projected oblique great circle cuts the primitive circle in an angle equal to the inclination of the plane of that oblique circle to the plane of projection.

For Fa is equivalent to FA the inclination.

And Fa measures the angle FH a , since FH, H a are each 90° . (389)

427. COROL. IV. The distance between the projections of a great circle and any of its parallels is equivalent to their distance on the sphere.

Thus the projection ak is equivalent to AK.

428.

PROP. V.

Any point of a sphere stereographically projected, is distant from the centre of projection, by the tangent of half the arc intercepted between that point and the pole opposite to the eye: The semidiameter of the sphere being made radius. Plate I.

Let $c b e b$ be a great circle of the sphere whose centre is c , GH the plane of projection cutting the diameter of the sphere in b , B ; E , c , the poles of the section by that plane; and a the projection of A . Then is ca equal to the tangent of half the arc AC .

DEM. Draw CF , a tangent to the arc $CD = \frac{1}{2}$ arc CA , and join cF . Now the triangles CFc , cae , are congruous: For $cc = ce$, $\angle c = \angle eca = \text{right } \angle$, $\angle ccf = \angle cea$: Therefore $ca = CF$. Consequently ca is equal to the tangent of half the arc CA .

429.

PROP. VI.

The angle made by the intersection of the circumferences of two circles in the same plane, is equal to the angle made by tangents to those circles in the point of section; and also is equal to the angle made by their radii drawn to that point. Plate I.

Let CE , CD , be two arcs of circles in the same plane cutting in the point C ; AC , BC , their radii; GC , FC , tangents at the point C . Then is the curve lined angle $ECD = \angle GCF = \angle ACB$.

DEM. Since the radii AC , BC , are at right angles to their tangents GC , FC (209); and are also at right angles to the arcs CE , CD . (219) Therefore the position of the tangents and arcs at the point C are the same; and therefore the $\angle ECD = \angle GCF$. Also the $\angle ACB + \angle BCG = (\text{right } \angle =) \angle FCG + \angle BCG$. Therefore the angle ACB is equal to the angle FCG , by taking away the common angle BCG . Consequently $\angle ECD = \angle GCF = \angle ACB$.

430. SCHOLIUM. If the arcs CE , CD , were in different planes, the same would hold true with regard to their tangents.

For suppose the circle CD to revolve on the fixed radius BC , still cutting the circle CE in C : Then the tangent CF revolving with it, has still the same inclination to BC : And as the inclination of the planes of the circles vary, so much will the inclination of the tangents vary.

Therefore the angle made by the tangents, in all positions of the circular planes, is the same as the angle made by their circumferences.

431. COROL. Hence if a plane touch a sphere, at the point where two circles thereof intersect one another, the tangents to both circles will lie in that plane; and consequently, in all oblique positions, a right line perpendicular to one tangent will cut the other tangent.

432.

432.

PROP. VII.

The angle which any two circles make when stereographically projected, is equal to the angle which those circles make on the sphere. Plate I.

Let $IACE$ and ABL be two circles on a sphere intersecting in A ; E the projecting point, and RS the plane of projection whereon the point A is projected in a , in the line IC , the diameter of the circle ACE .

Also let DH , FA , be tangents to the circles ACE , ABL .

Then if ad , af , are the projections of the tangents AD , AF ; the projected $\angle daf$ will be equal to the spheric angle BAC .

DEM. As the tangents AD , AF , are obliquely posited in a plane touching the sphere in A . (431)

From any point D in the tangent AD , draw DF perpendicular to AD meeting the tangent AF in F ; draw DG parallel to IC meeting EA produced in G , and draw FE cutting the plane of projection in f .

Now as the tangent DH is in the same plane with the circle ACE passing thro' the eye E , the line AD will be projected in the line ad .

And as $\angle DGE = \angle dae$ (185) $= \angle EAH$. (215, 220)

And $\angle EAH = \angle DAG$. (183)

Therefore $\angle DGE = \angle DAG$. And $DG = DA$. (194)

Also DF being perpendicular to AD , is at right angles to the plane ACE ; and consequently is in a parallel position to the plane RS .

Therefore df the projection of DF is at right angles to da the projection of DA .

Therefore the triangles dfa , DFG , are parallel sections of the pyramid $DFGE$: So that $ad : df :: (DG =) DA : DF$. (285)

Now the triangles ADF , daf , having an equal angle in each, and the sides about that angle proportional, are similar. (251)

Consequently the angle $daf =$ angle DAF .

But $\angle DAF = \angle BAC$ (429): Therefore $\angle daf = \angle BAC$.

433.

PROP. VIII.

The distance between the poles of the primitive circle and an oblique circle, in stereographic projections, is equal to the tangent of half the inclination of those circles; and the distance of their centres is equal to the tangent of their inclination: The semidiameter of the primitive circle being made radius. Plate I.

Let AC be the diameter of a circle whose poles are P and Q , and inclined to the plane of projection in the angle AIF .

And let a , c , p , be the projections of the points A , C , P .

Also let HaE be the projected oblique circle, whose centre is q .

Now when the plane of projection becomes the prim. circle whose pole is I .

Then is $Ip =$ tangent of half $\angle AIF$, or of half the arc AF .

And $Iq =$ tangent of AF , or of the $\angle FHa = AIF$.

DEM. For $AH + HP = AH + AF$. Therefore $HP = AF$.

But $Ip =$ tangent of half HP , or of half AF . (428)

Again. As AC is projected in ac , then q the middle of ac , is the centre of the projected circle, and of its representative HaE . (425)

Draw Eq produced to r : Then as $qa = qe$; the $\angle qea = \angle qae$. (104)

R 2

But

But the $\angle qae$ is measured by half the arc EFA . (220)
 Therefore the arc $AHr = \text{arc } AFE$ (143): And as the arc $AHP = FQE$.
 Therefore $Pr = AF = HP$; and $HPr = \text{twice the arc } AF$.
 Therefore (210) the $\angle IEq = \angle AIF$, the inclination of the circles.
 But Iq is the tangent of the $\angle IEq$, EI being the radius.

434. COROL. Hence the radius of an oblique circle is equal to the secant of the obliquity of that circle to the primitive.
 For Eq is the secant of the angle IEq , to the radius EI .

435. PROPOSITION IX.

If thro' any given point in the primitive circle an oblique circle be described; then the centres of all other oblique circles passing thro' that point, will be in a right line drawn thro' the centre of the first oblique circle at right angles to a line passing thro' that centre, the given point, and the centre of the primitive.

Let $GACE$ be the primitive circle, $ADEI$ a great circle described thro' D , its centre being B .

HK is a right line drawn thro' B , perpendicular to a right line CI passing thro' D , B , and the centre of the primitive circle.

Then the centres of all other great circles FDG passing thro' D will fall in the line HK .

DEM. For if E be the projecting point, the circle $EDAI$ will be the projection of a circle whose diameter is NM . (418)

Therefore D and I are the projections of N , M , which are opposite points on the sphere; or of points at a semicircle's distance.

Therefore all circles passing thro' D and I must be the projections of great circles on the sphere.

But DI is a chord in every circle passing thro' the points D , I .

Consequently the centres of all those circles will be found in HK drawn perpendicularly thro' B the middle of DI . (208)

436. PROPOSITION X.

Equal arcs of any two great circles of the sphere, will be intercepted between two other circles drawn on the sphere thro' the remotest poles of those great circles. Plate I.

Let $PBEA$ be a sphere, whereon AGB , CFD , are two great circles, whose remotest poles are E , P ; and thro' these poles let the great circle $PBEC$, and small circle PGE , be drawn. intersecting the great circles AGB , CFD , in the points B , G , and D , F .

Then are the intercepted arcs BG and DF equal to one another.

DEM. For the arcs $ED + DB = \text{arcs } PB + DB$; therefore $ED = PB$.

And the arcs $EF + FG = \text{arcs } PG + FG$ (399); therefore $EF = PG$.

For the points F and G are equally distant from their poles P , E .

Also the $\angle DEF = BPG$; for intersecting circles make equal angles at the sections. (411)

Therefore the triangles EDF and PGB are congruous. (407)

Therefore the arc $BG = \text{arc } DF$.

437.

PROP. XI.

If lines be drawn from the projected pole of any great circle, cutting the peripheries of the projected circle and plane of projection, the intercepted arcs of these circumferences are equal. Plate I.

On the plane of projection AGB , let the great circle CFD be projected in $cf d$, and its pole P in p : Then the lines pd, pf , being drawn, cutting the circumference of the plane of projection in B, G , and that of the projected circle in d, f ; the arc $GB = \text{arc } fd$.

DEM. For as the points D, F , are projected in d, f . (418)

The arc fd is equivalent to the arc FD .

But the arc FD is equal to the arc GB . (435)

Therefore the arc GB is equal to the arc fd .

438.

PROP. XII.

The radius of any small circle, whose plane is perpendicular to that of the primitive circle, is equal to the tangent of that lesser circle's distance from its pole; and the secant of that distance, is equal to the distance of the centres of the primitive and lesser circle. Plate I.

Let P be the pole, and AB the diameter of a lesser circle, the plane being perpendicular to the plane of the primitive circle, whose centre is c : Then d being the centre of the projected lesser circle, dA is equal to the tangent of the arc PA , and $dC = \text{secant of } PA$.

DEM. Draw the diameter ED parallel to AB , and thro' P draw cb . Now E being the projecting point, the diameter AB is projected in ab . (402)

And d the middle of ab is the centre of a circle on ab . (419)

Then a right line drawn from D thro' A , will meet b : (213)

And draw CA, dA .

Now the right angled triangles DCb, DAE , having the angle D common; the $\angle Dbc = \angle DEA$. (188)

But $\angle DEA = \frac{1}{2} \angle DCA$; and $\angle Dbc = \frac{1}{2} \angle Adc$: (210)

Therefore $\angle DCA = \angle Adc$.

Now $\angle DCA + \angle Acd = \text{right angle}$;

Then $\angle Adc + \angle Acd = \text{right angle}$: Therefore $\angle CA d$ is right (186)

Consequently $dA = \text{radius of the circle } AaB$, is the tangent of the arc PA , to the radius CA . (209)

And dC , the distance of the centres, is the secant of the arc AB . (300)

439. COROL. Hence the tangent and secant of any arc of the primitive circle, belongs also to an equal arc of any oblique circle; those arcs being reckoned from their intersection.

For the arc Pc of every oblique circle intercepted between P and the arc of the small circle AaB , is equivalent to the arc PA of the primitive circle: Because the arc AaB is equally distant from its pole P . (385)

SECTION

SECTION III.

SPHERICAL GEOMETRY.

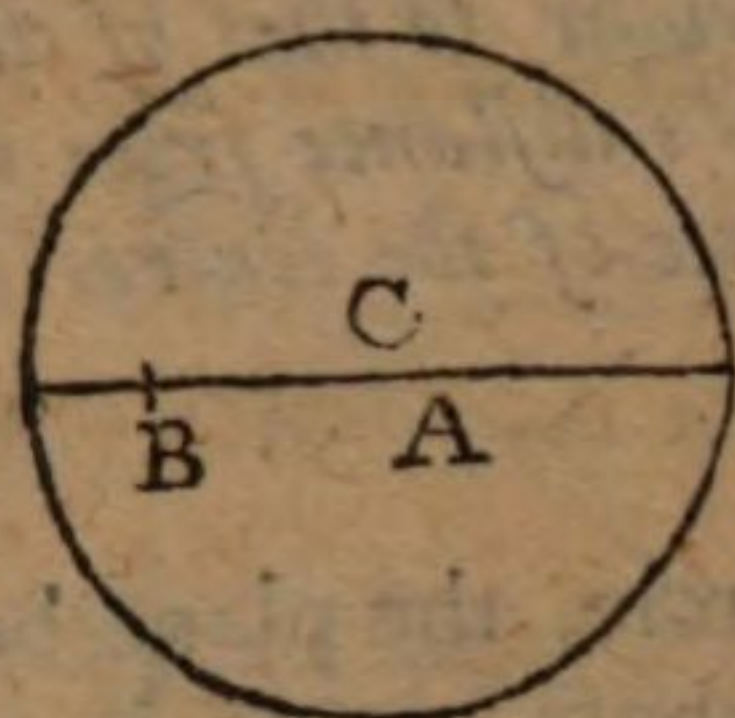
Spheric Geometry, or spheric projection, is the art of describing or representing on the plane of a great circle, such circles or arcs of circles as are usually drawn upon a sphere; and of measuring such arcs and their positions to one another when projected.

440.

PROBLEM I.

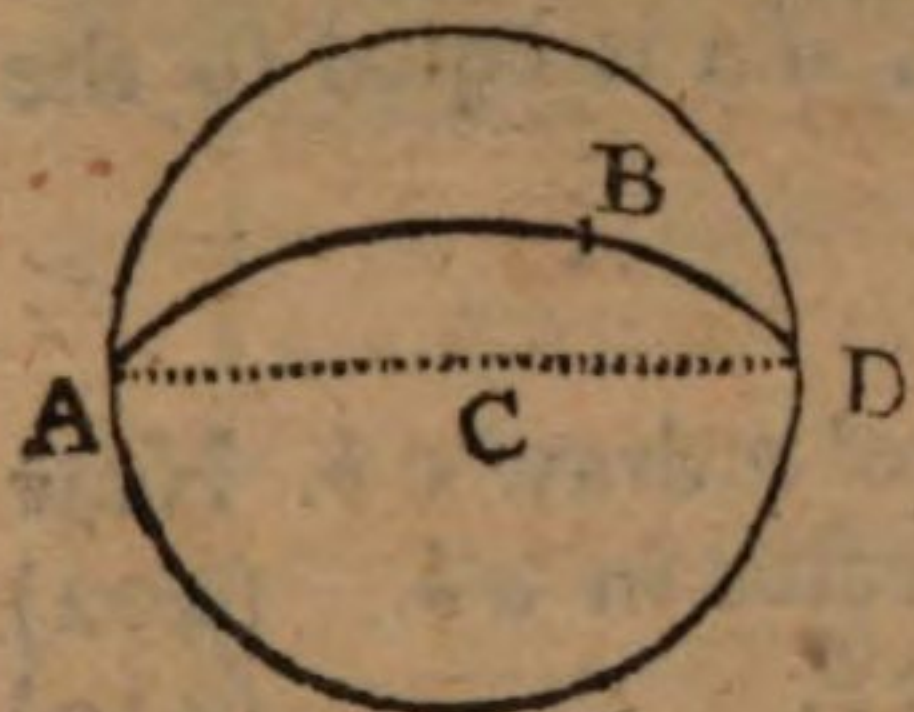
To describe a great circle that shall pass thro' two given points in the primitive circle, or plane of projection.

Let the given points be A, B; and C the centre of the prim. circle.



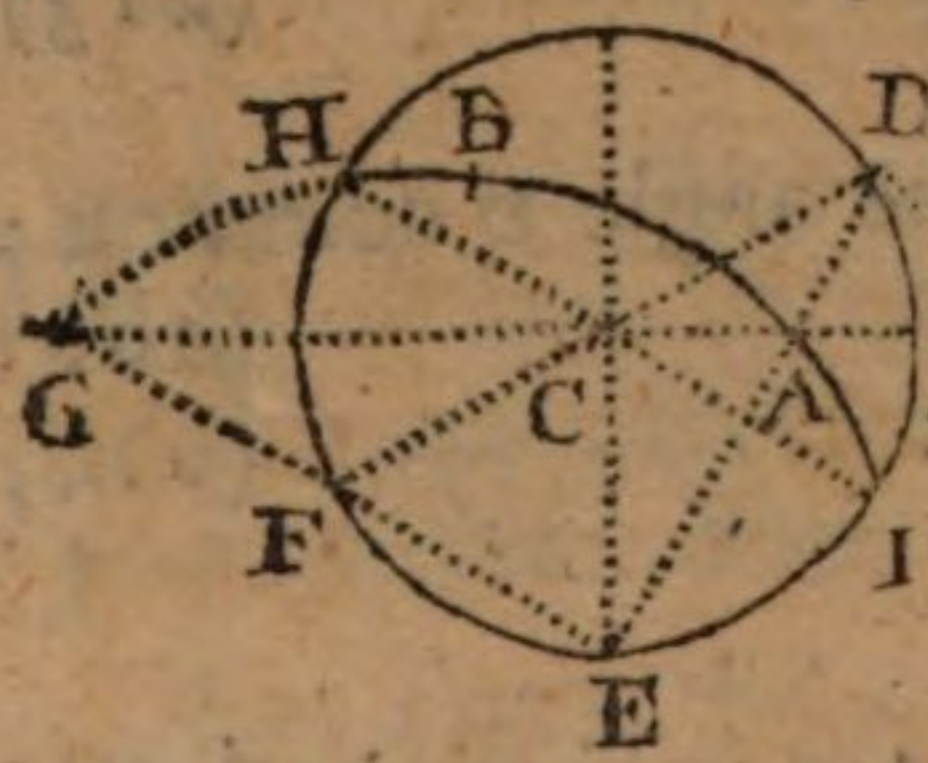
CASE 1. *When one point A is the centre of the primitive circle.*

CONST. A diameter drawn thro' the given points A, B, will be the great circle required. (395)



CASE 2. *When one point A is in the circumf. of the primitive circle.*

CONST. Thro' A draw a diameter AD. Then an oblique circle described thro' the three points A, B, D, (163) will be the great circle required. (422)



441. CASE 3. *When neither point is at the centre, or circumference of the primitive circle.*

CONST. Thro' one point A, and the centre C, draw AG, and draw CE at right angles to AG.

A ruler by E and A gives D; by D and C gives F; and by E and F gives G, in AC continued.

Thro' the three points G, B, A, describe a circumference (163) cutting the primitive circle in H and I.

Then the oblique circle HBAI will be the great circle required.

For AG may be taken as the projection of the great circle FD. (402)

Therefore A and G are the projections of opposite points on the sphere. (412)

Consequently all circles passing thro' G and A will be the representatives of great circles on the sphere.

442.

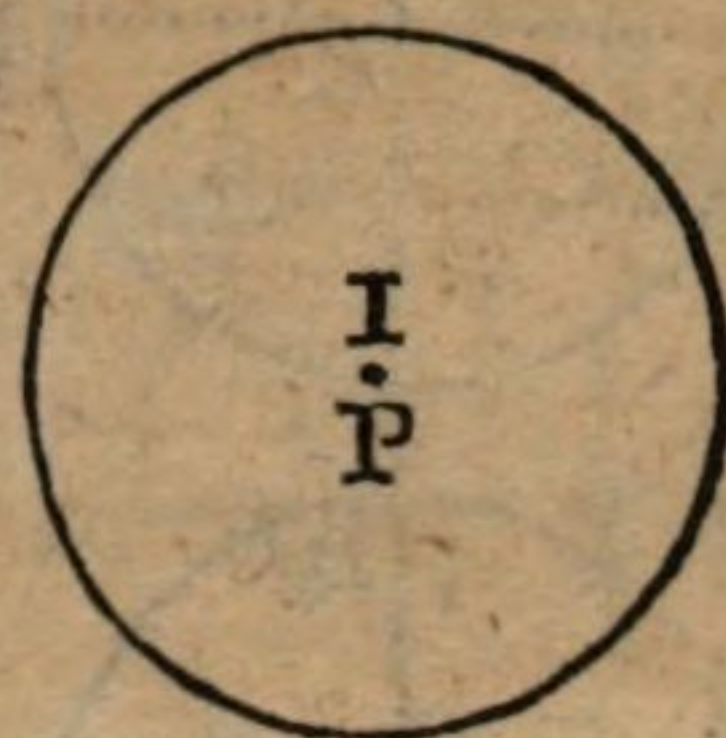
P R O B L E M II.

About any given point as a pole, to describe a great circle in a given primitive circle.

Let P be the given point, and I the centre of the primitive circle.

CASE 1. When the given pole P is in the centre of the primitive circle.

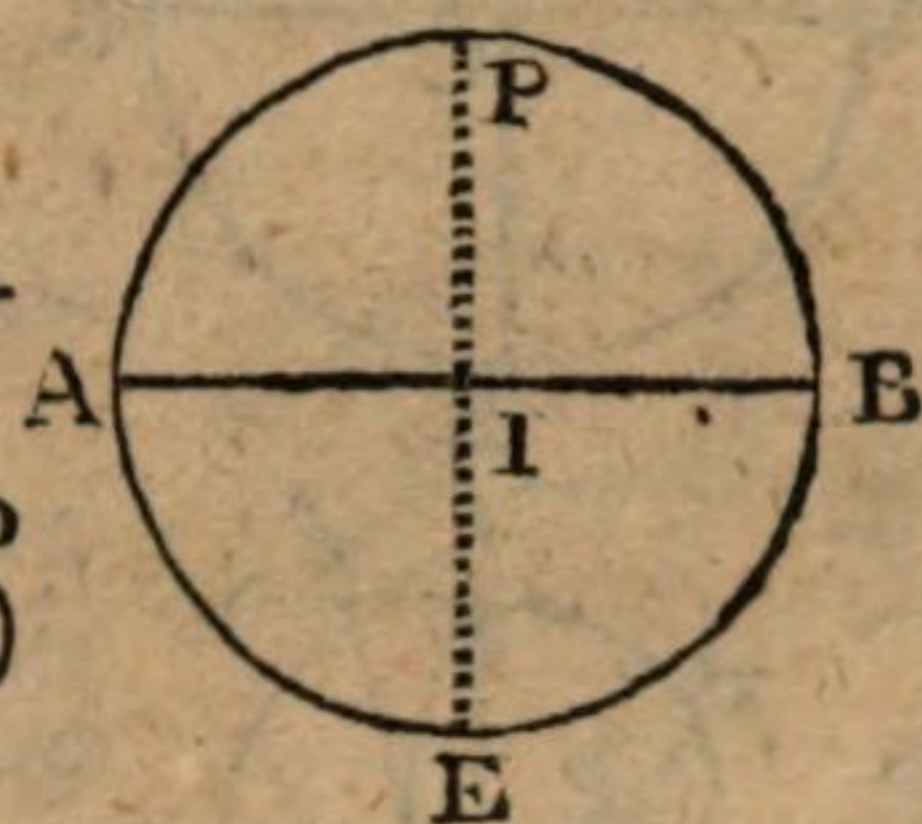
CONST. The primitive circle will be the great circle required. (393)



CASE 2. When the given pole P is in the circumference of the primitive circle.

CONST. Thro' the given pole P , draw PE a diameter to the primitive circle.

Then another diam. AB , drawn at right angles to PE , will be the great circle required. (400, 395)



443. CASE 3. When the given pole P is neither in the centre or circumference of the primitive circle.

CONST. Thro' P draw a diameter bd , and another BE at right angles to bd ; then a ruler by E and P gives p .

Make the arc $pA = 90^\circ$; a ruler by E and A gives a in the diam. bd .

Make the arc $pD = \text{arc } pB$; a ruler on E and D gives c in db produced.

Then on c with the radius ca describe BaE .

For, As E is the projecting point, and P the projected pole;

Therefore p is the pole of the circle AF to be projected. (424)

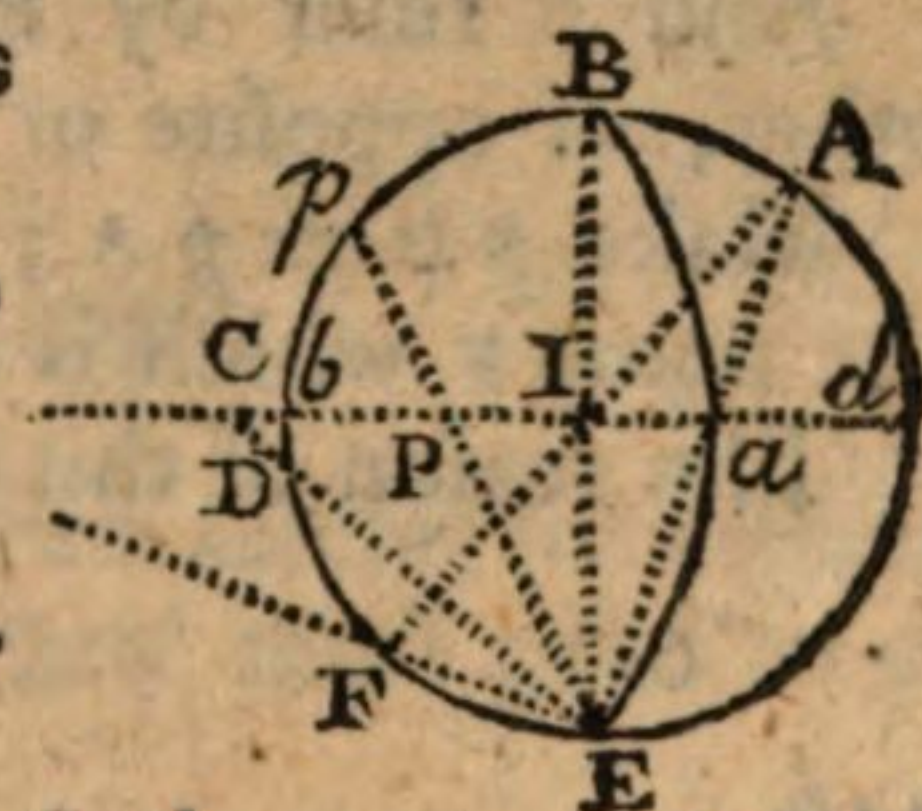
And BaE is the projection of the circle AF . (418)

Now $\angle caE$ is measured by half the arc $A d E$. (220)

But $\text{arc } ABD = \text{arc } A d E$: For $A p = (B d =) d E$; and $p D = A d$ by const.

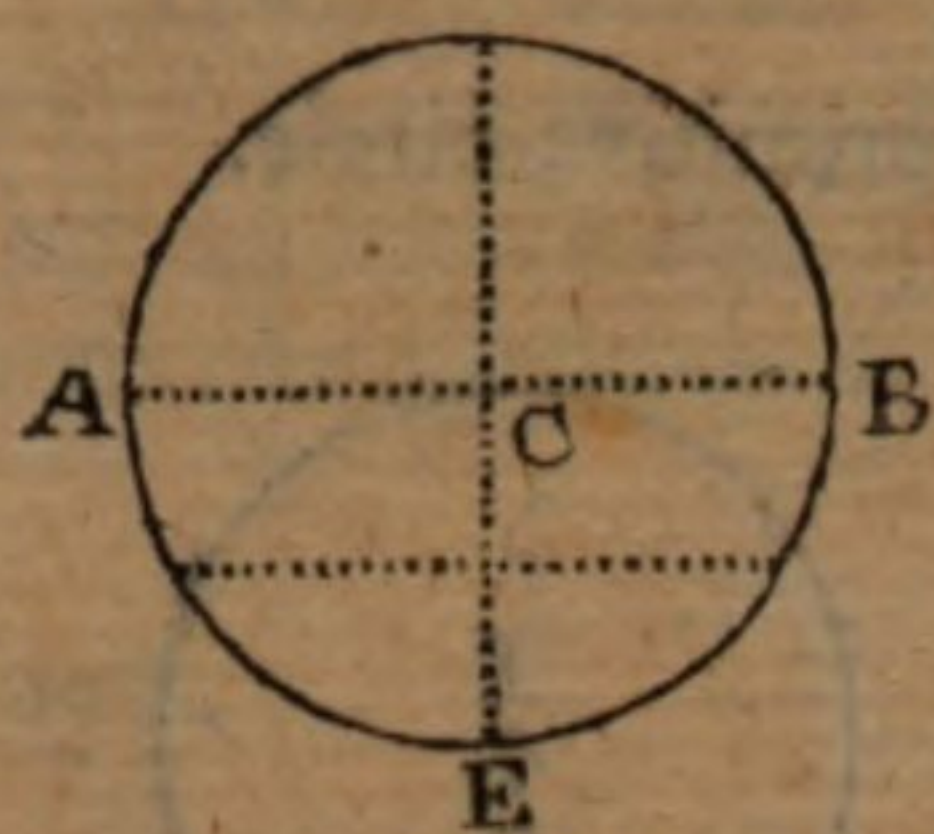
Therefore $\angle AEC = \angle caE$; and $CE = ca$. (194)

Consequently c is the centre required.



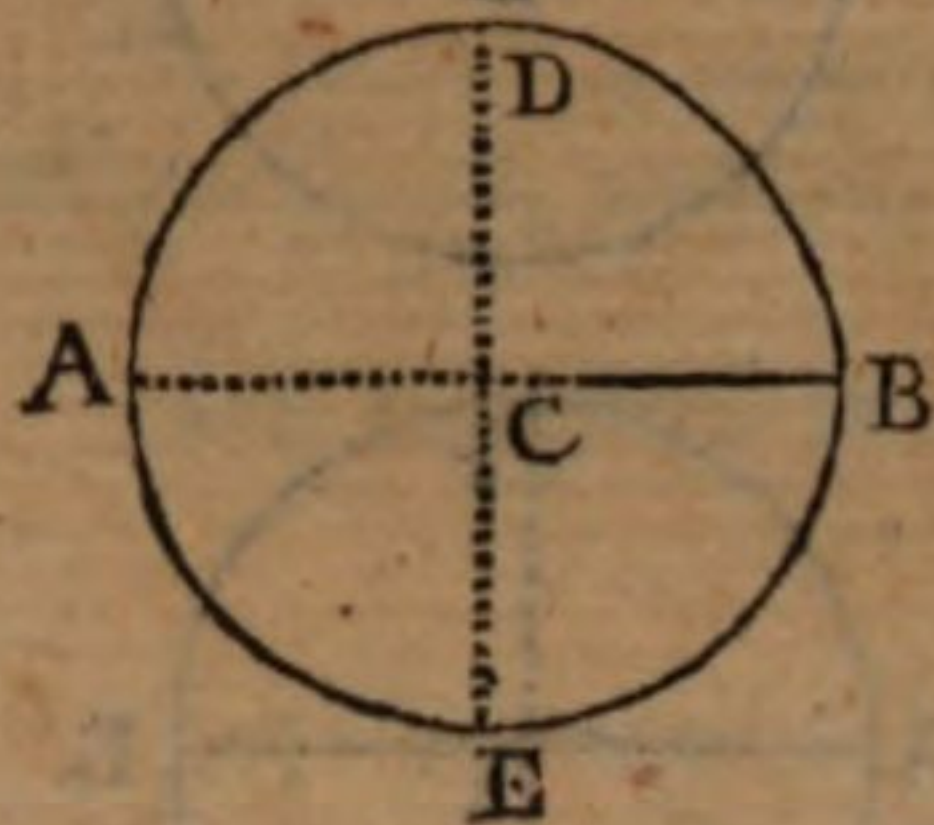
A projected circle being given, to find its poles.

CASE 1. *When the given circle AEB is the primitive.*



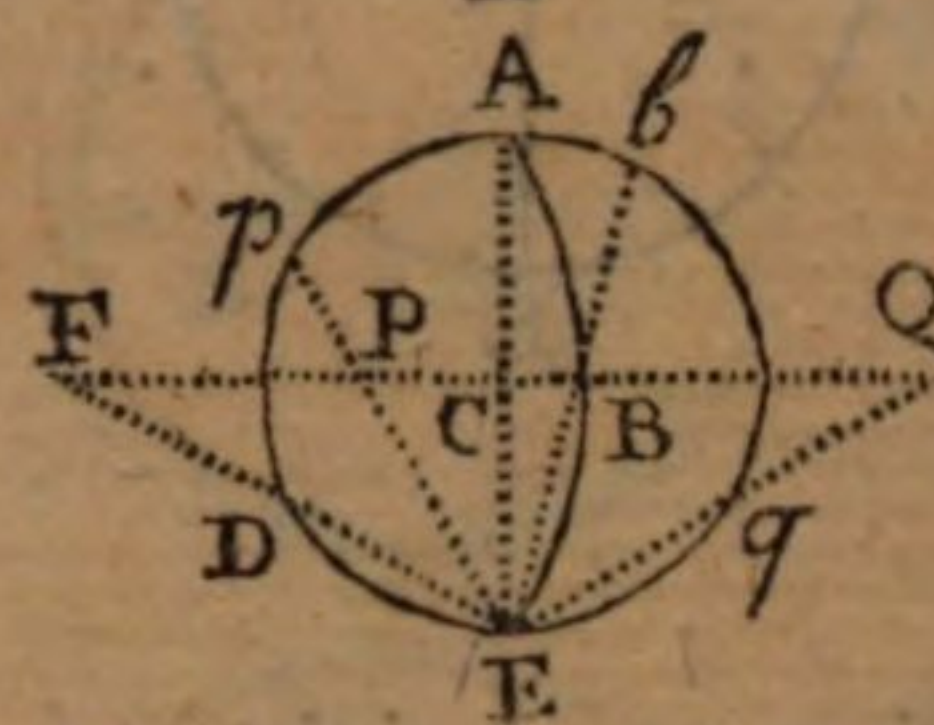
CONST. Find the centre C, (161) and it is the pole sought.

CASE 2. *When the given circle ACB is a right circle.*



CONST. Draw a diameter ED at right angles to AB, and the ends or points D, E, of that diameter are the poles required.

445. CASE 3. *When the given circle ABE is oblique.*



CONST. Thro' the intersections of the primitive and oblique circles draw a diameter AE, and another at right angles to AE, cutting the given oblique circle in B.

A ruler by E and B gives b ; make $b p$, $b q$, each = chord of 90° .

A ruler by E and p gives, in the diameter thro' B, the point P, which is the pole required.

And a ruler by E and q gives, in CB continued, the point Q for the other, or opposite or exterior pole.

Make $p D = p A$; then a ruler by E and D gives, in BC continued, the point F which is the centre of the oblique circle ABE.

The reason of this operation is evident from that of the last Prob.

446.

PROBLEM IV.

To measure any arc of a projected great circle: Or in a given projected great circle to take an arc of a given number of degrees.

GENERAL SOLUTION. Find the pole of the given circle. (444)

From that pole draw lines thro' the ends of the proposed arc, cutting the primitive circle.

Then the intercepted arc of the primitive circle applied to the scale of chords will give the measure sought.

Thus, If AB be the arc to be measured, and P the pole of the given circle DAF.

Then lines drawn from P thro' A and B, gives the arc ab in the primitive circle, corresponding to AB in the projected circle.

Now

Now if an arc of a given number of degrees was to be taken from a given point A, in the given projected circle DAF.

Draw from the pole P thro' A, the line Pa to the primitive circle.

Apply the given number of degrees from a to b.

Draw Pb, and the intercepted arc AB will contain the degrees proposed.

447. Any number of degrees are readily applied to a right circle by the scale of half tangents. Thus,

When the distance of the point A from the centre C is known, and the given quantity of the arc is to be laid from A towards F.

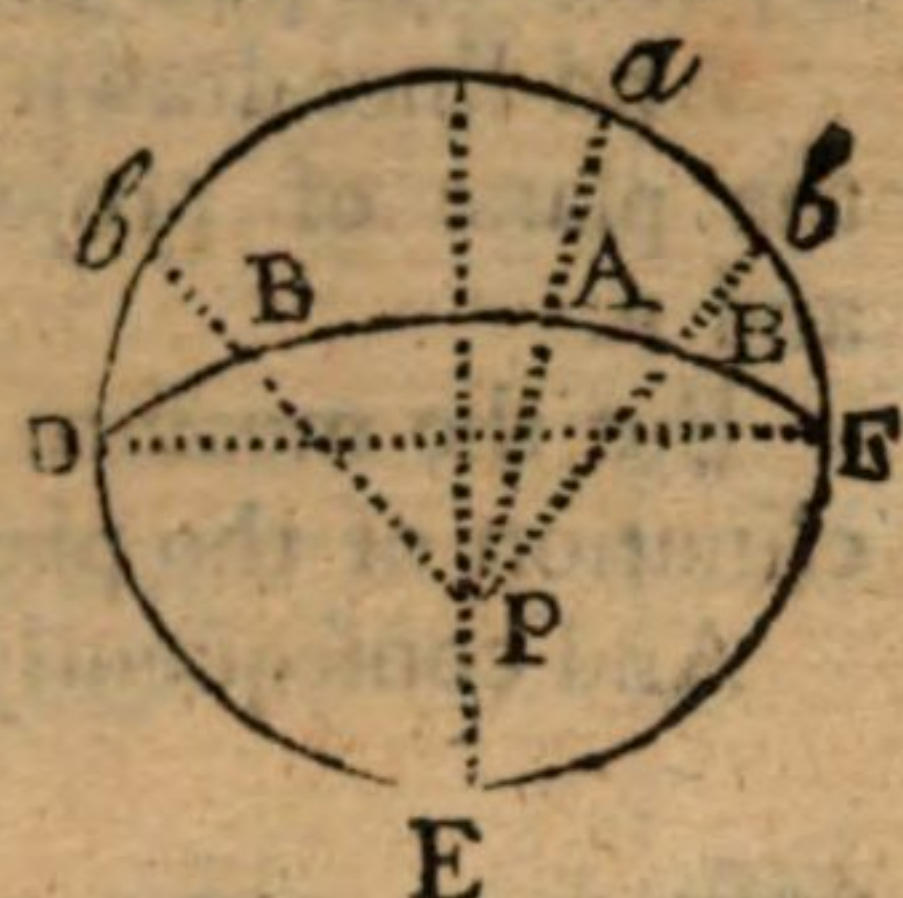
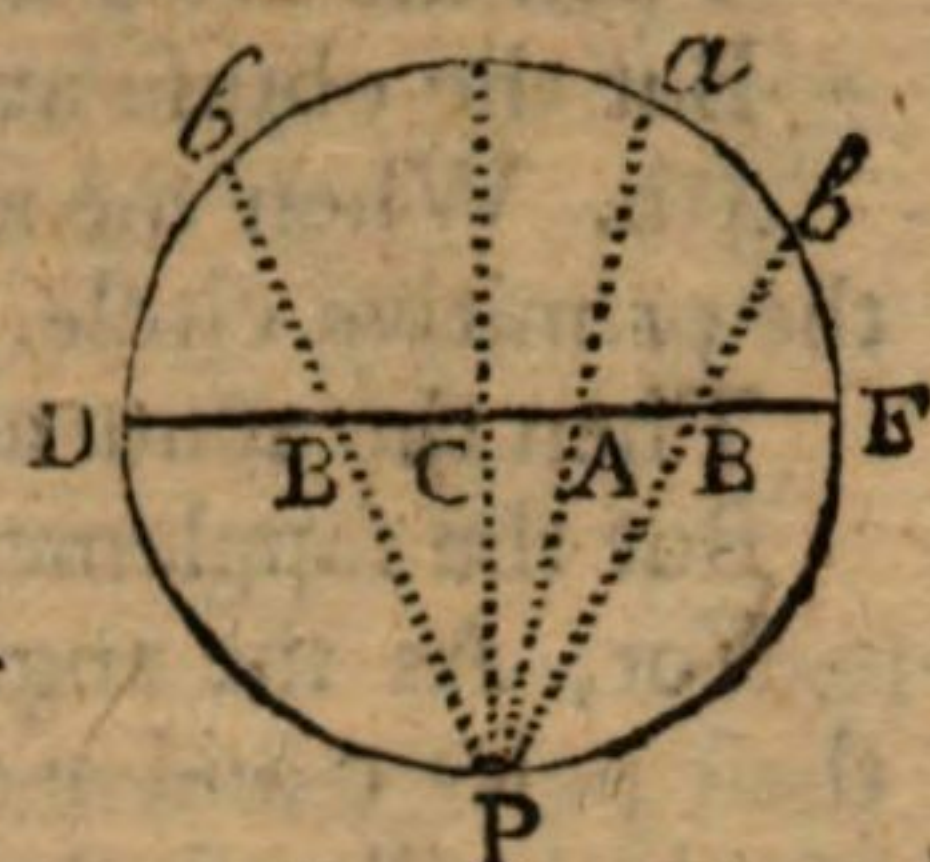
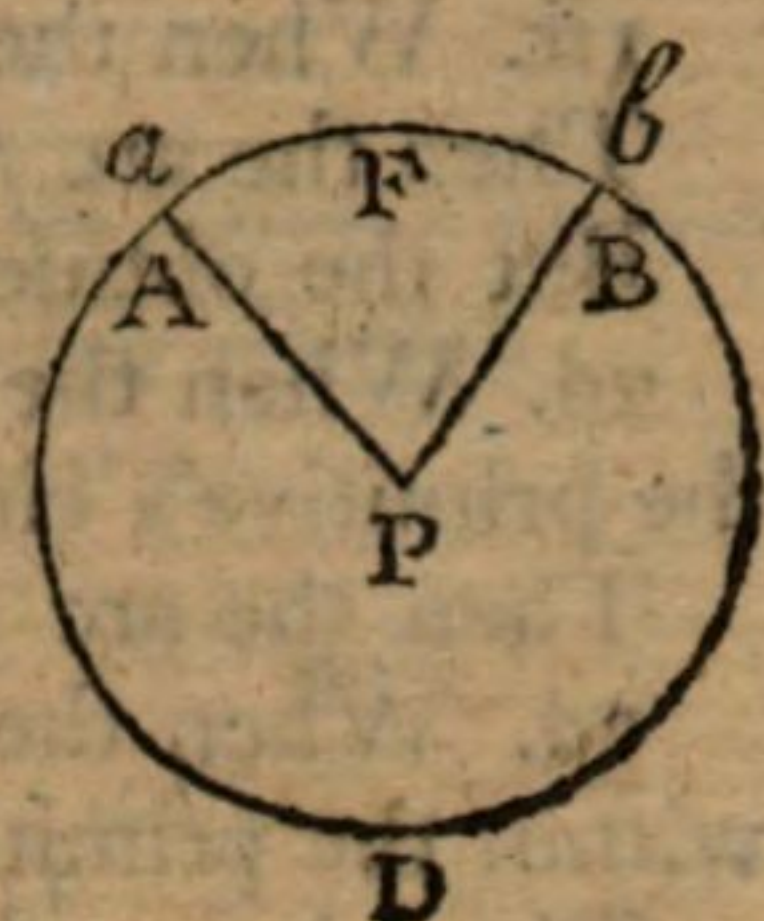
To the known distance CA add the proposed arc AB, the degrees in the sum taken from the scale of half tangents and laid from C to B, will make the arc AB equal to the degrees proposed.

But when the arc AB is to be laid from A towards D,

Then the difference between the arcs AB and AC taken from the scale of half tangents and laid towards D from C to B will make the arc AB equal to the degrees proposed.

The reason of all these operations is evident from art. 437.

Note. The half, or semi-tangents are only the tangents of half the arcs the scale of tangents is made to; their construction depends on art. 428. On the *plane scale* they are put under the Tangents, and marked s. t.



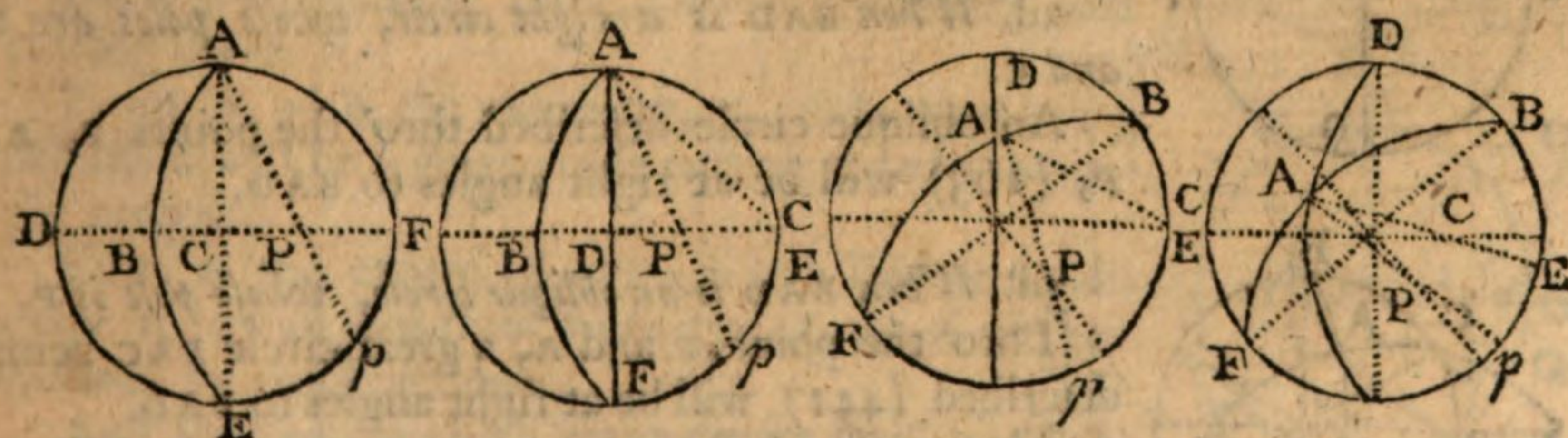
448.

PROBLEM V.

To measure any projected spherical angle.

GENERAL SOLUTION. Find the poles of the two circles which form the angle; and from the angular point draw lines thro' those poles to cut the primitive circle.

Then the measure of that angle, if acute, will be the intercepted arc of the primitive circle; or the supplement of that arc will be the measure of the angle when obtuse.



Let the proposed angle be DAB, formed by the great circles AD, AB, whose poles are C and P; and lines drawn from the angular point A thro' the poles C and P cut the primitive circle in E and p.

S

1 ft.

1st. When the angle is formed by the primitive and oblique circles.

Then the arc pE measures the acute angle DAB .

But the obtuse angle BAF is measured by the suppl. of pE .

2d. When the angle is formed by right and oblique circles meeting in the primitive's circumference.

Then the arc pE measures the angle DAB .

3d. When the angle is formed by right and oblique circles meeting within the primitive circle.

Then the arc pE measures the acute angle DAB .

But the obtuse angle DAF is measured by the supplement of pE .

4th. When the angle is formed by two oblique circles meeting within the primitive circle.

Then the acute angle DAB is measured by the arc pE .

But the supplement of pE measures the obtuse angle DAF .

For, As the angular point A is in both circles, and 90° distant from their poles c and P (399). Therefore a great circle described about A as a pole, will pass thro' the poles c and P .

And lines drawn from A thro' c and P , cut off, in the circumference of the plane of projection, an arc equal to the distance of the poles c and P . (437)

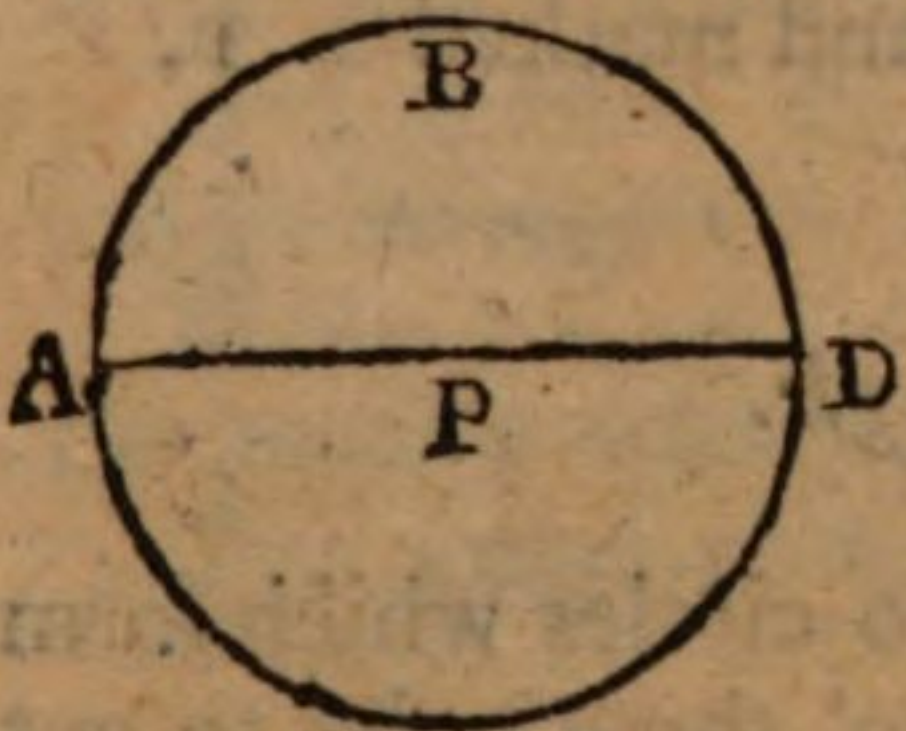
But the measure of the distance of the poles c , P , is equal to the inclination of the planes of the circles AD , AB ; (413)

And consequently measures the angle DAB .

449.

PROBLEM VI.

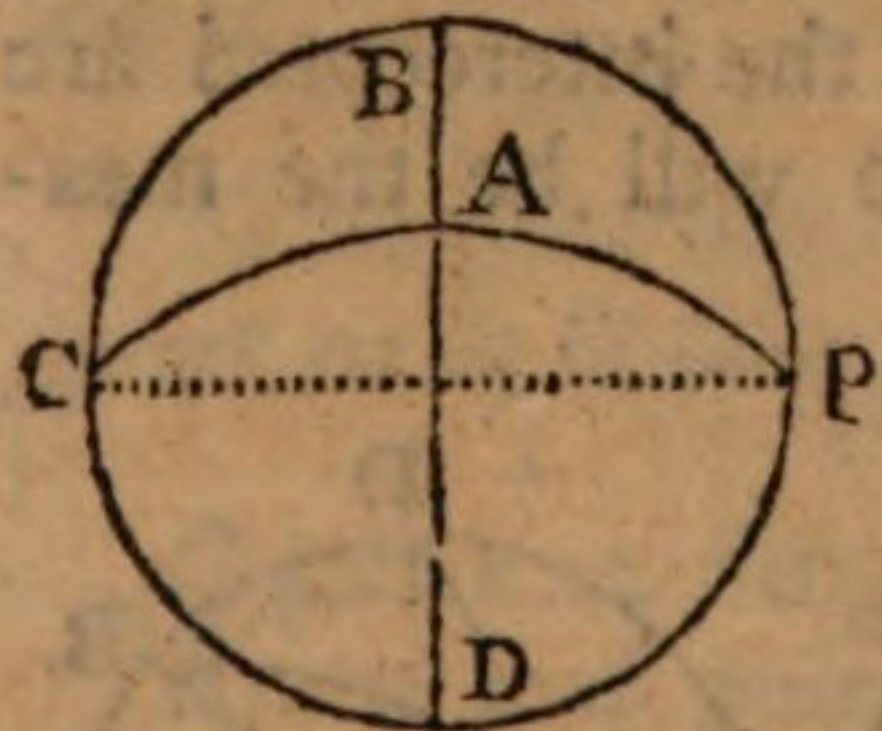
Thro' a given point in any projected great circle, to describe another great circle at right angles to the given one.



GENERAL SOLUTION. Find the pole of the given circle.

Then a great circle described thro' that pole and the given point will be at right angles to the given circle.

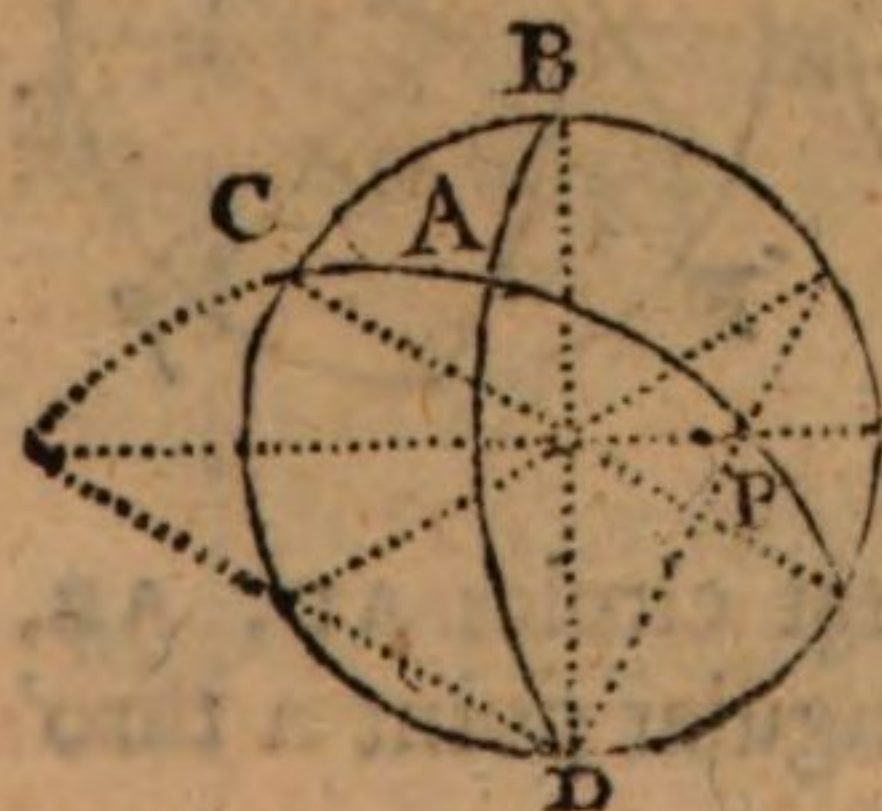
Let the given projected great circle be BAD ; and A the given point.



1st. When BAD is the primitive circle whose pole is P . A diam. thro' A will be perpendicular to BAD . (219)

2d. When BAD is a right circle, whose poles are P and C .

An oblique circle described thro' the points C , A , P , (163) will be at right angles to BAD .



3d. When BAD is an oblique circle, whose pole is P . Thro' the points P and A , a great circle PAC being described (441) will be at right angles to BAD .

The truth of these operations are evident from art. 414.

450.

450. PROBLEM VII.

Thro' any assigned point in a given projected great circle, to describe another great circle cutting the former in an angle of a given number of degrees.

Let P be a given point in any great circle APB.

1st. *When APB is the primitive circle.*

Thro' the given point P draw a diameter PE, and draw the diameter AB at right angles to PE.

Draw PD cutting AB in D, so that the angle CPD be equal to the angle proposed.

On D with the radius DP describe the great circle PFE,

Then will the angle APF contain the given degrees.

FOR the $\angle FPA =$ angle made by the radii PC, PD. (429)

And D being equally distant from P and E, is the centre sought.

451. Or thus. Make CD equal to the tangent of the given angle to the radius CP.

Or. Make PD equal to the secant of that angle.

452. 2d, *When APB is a right circle.*

Draw a diameter GH at right angles to APB.

Then a ruler by G and P gives *a* in the primitive circle.

Make $Hb = 2Aa$; a ruler by G and *b* gives C in AB.

Draw CD at right angles to AB.

Draw PD cutting CD in D, so that the $\angle CPD =$ comp. of the deg. given. (175)

On D with the radius DP describe a circle FPE; which will be a great circle making with APB the angle APF as required.

FOR, C is the centre of a great circle GPH. (445)

And the centres of all great circles thro' P, will be in CD. (435)

Now $\angle DPE = 90^\circ$. (219)

Therefore $\angle APF = \angle BPE$ (406) $=$ comp. CPD is the angle sought.

453. 3d. *When APB is an oblique circle.*

From the given point P, draw the lines PG, PC, thro' the centres of the primitive and given oblique circles.

Thro' C the centre of APB draw CD at right angles to PG. (150)

Draw PD, making the $\angle CPD =$ given deg. and cutting CD in D. (175)

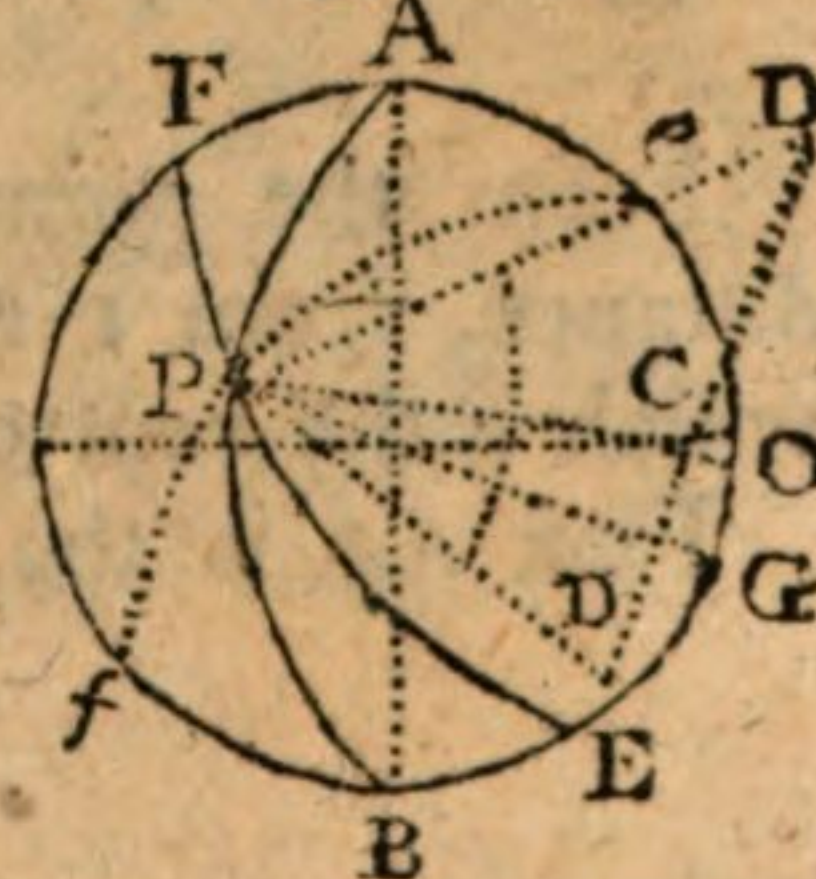
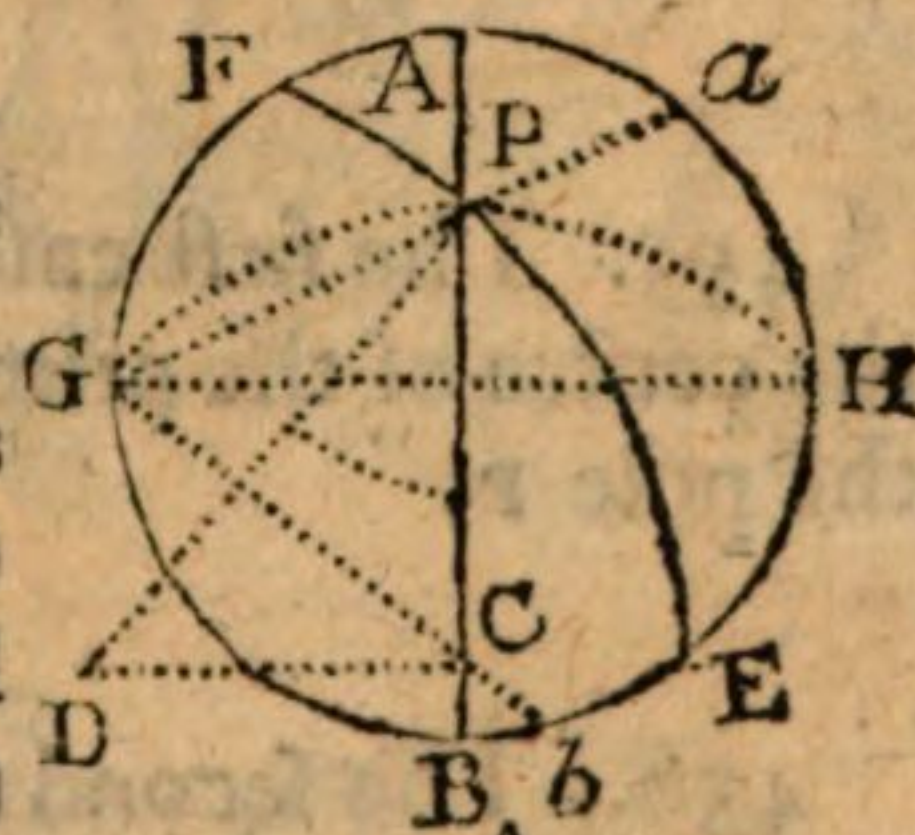
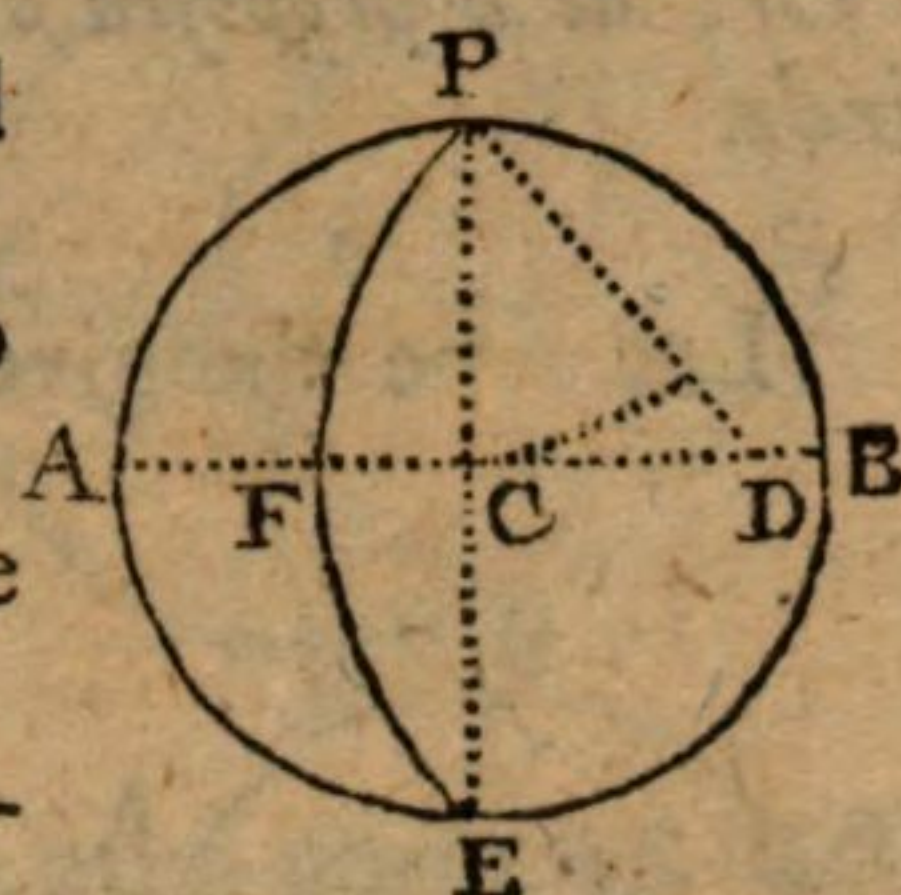
From D with the radius DP, a circle FPE being described will be a great circle cutting APB in the angle proposed.

FOR, C the centre of APB, is in a line perpendicular to PG drawn thro' P and the centre of the primitive, by construction.

And the centres of all great circles thro' P will be in CD. (435)

Now the $\angle CPD$ made by the radii PC, PD, contains the given degrees.

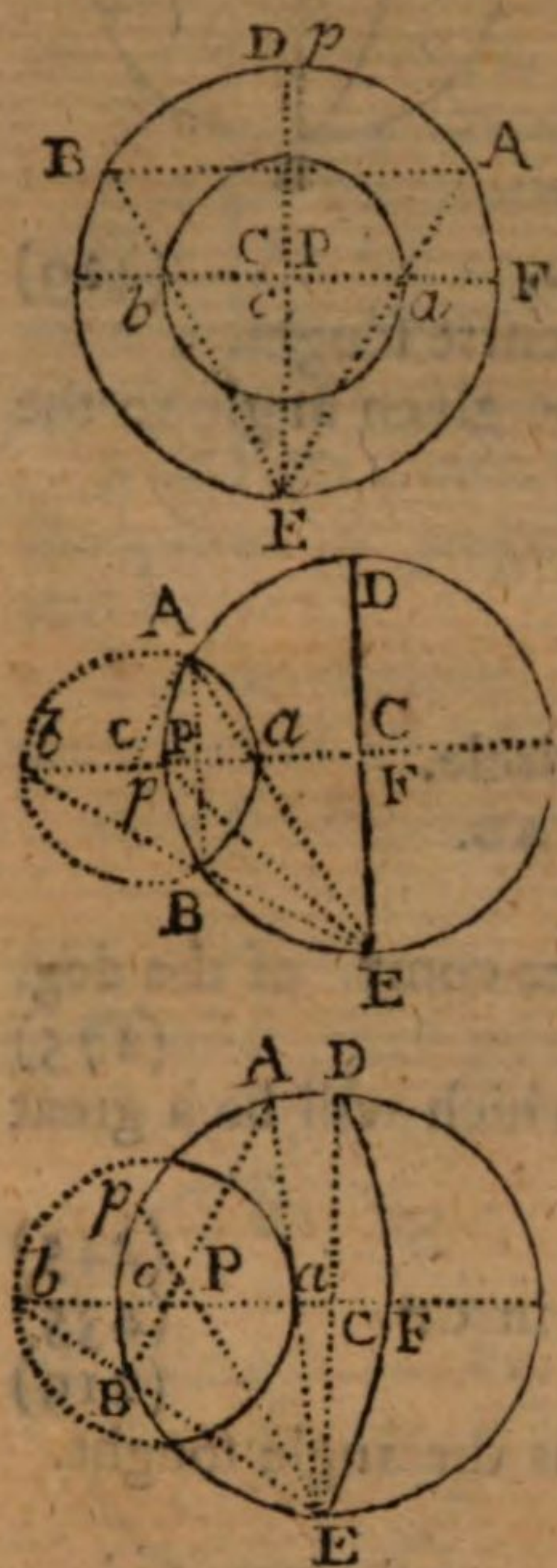
Therefore the angle APF is equal to the angle required. (429)



About any given projected pole, to describe a circle at a given distance from that pole.

Or, at a proposed distance from a given great circle, to describe a parallel circle.

Let P be the given pole, belonging to the given great circle DFE .



GENERAL SOLUTION. Thro' the given pole P and the centre C of the primitive circle, draw a diameter, and another DE at right angles to it.

A ruler on E and P gives p in the primitive circle.

Make $pA = pB$, equal to the proposed distance from the pole.

A ruler on E and A , E and B , will cut the diameter CP in a and b .

Bisect ab in c ; and on c as a centre describe a circle passing thro' a and b , which will be the circle required.

But when the parallel circle is to be at a proposed distance from the given great circle DFE .

Find p as before; and make $pA = pB$ equal to the complement of the proposed distance; the rest as above.

For p is the pole whose projection is P . (424)

But p is the pole of a circle whose diameter AB is projected in ab . (402)

Therefore c , the middle of ab , is the centre of the projected circle. (419)

455. The first case is readily done, by describing the small circle about the centre of the primitive circle with the tangent of half its distance from the pole P .

456. The second case is soonest performed thus.

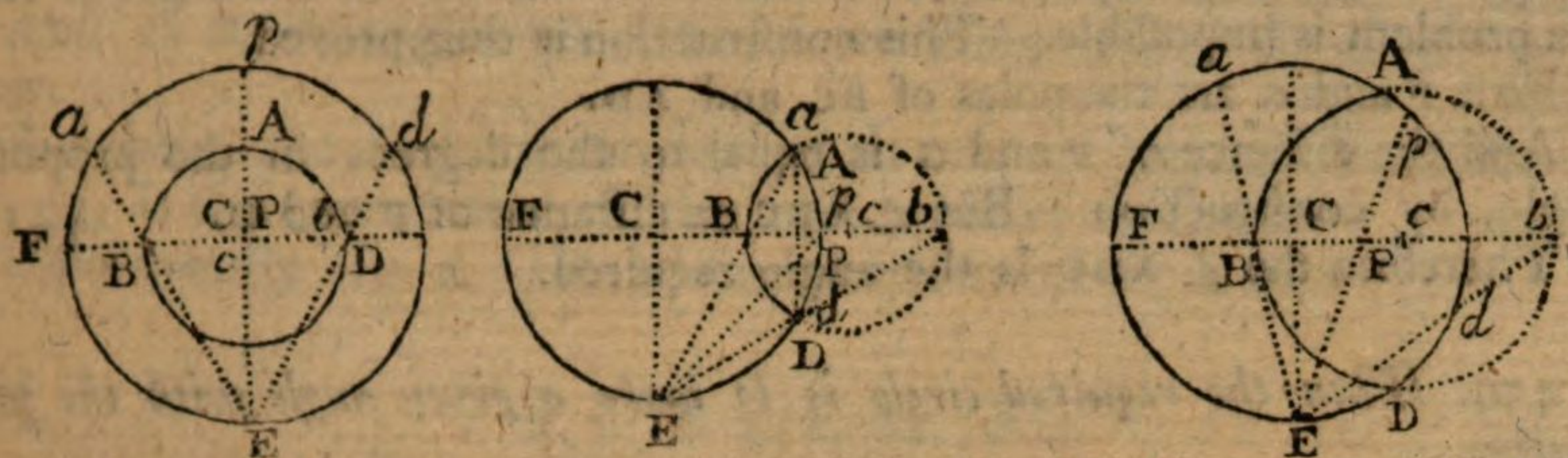
From the points A , B , (found as above), with the tangent of their distance, from P the pole of the right circle, describe arcs cutting in c , which is the centre of a small circle parallel to the right circle DFE .

For Ap is the tangent of the arc AP . (438)

457.

PROBLEM IX.

The primitive circle, and the projection of a small circle being given; to find the pole of that small circle.



Let c be the centre of the primitive circle, and ABD a projected small circle, whose centre is c , and radius cB .

GENERAL SOLUTION. Thro' c the centre of the small circle and c the centre of the primitive, draw a diameter CF , and another CE at right angles to it.

Find the projected diameter $Bb = 2cB$.

Lines drawn from E thro' B and b , cut the primitive circle in a, d ; then bisect the arc ad in p .

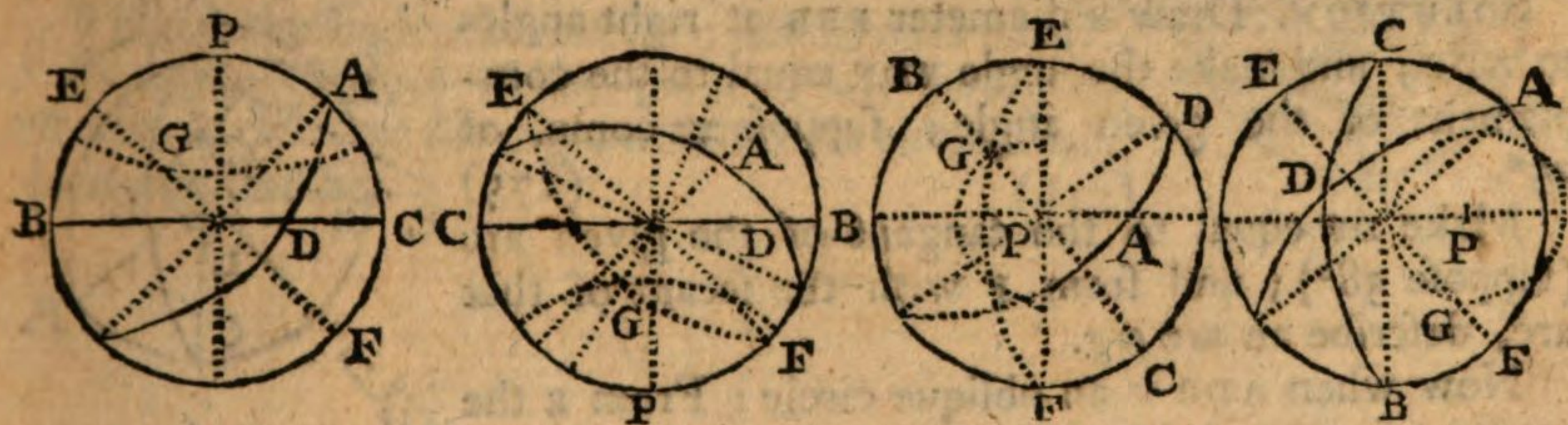
A ruler by E and p cuts the diameter Bb in P , the pole sought.

THE truth of this construction is evident from the last.

458.

PROBLEM X.

Thro' any point in the plane of projection, or primitive circle, to describe a great circle that shall cut a given great circle in any angle proposed: Provided the measure of that proposed angle is not less than the distance between the given point and circle.



Let the given point be A , thro' which a circle is to be described to cut a given great circle BDC , whose pole is P , in an angle equal to a proposed number of degrees.

GENERAL SOLUTION. About the given point (A) as a pole, describe a great circle EGF . (442)

About (P) the pole of the given circle BDC , describe a small circle at a distance equal to the given angle, cutting the great circle EGF in G . (454)

About the point G as a pole, describe a great circle cutting the given circle BDC in D . Then will ADC be the angle required.

Note.

Note. When the given angle is equal to the distance between the given point and circle, the problem is limited; when the measure of the angle is greater, the problem has two solutions by the circle described cutting the given one in two points: But when the measure of the angle is less, the problem is impossible. This construction is thus proved.

For P and G are the poles of BC and AD .

And the distance of P and G is equal to the degrees in the proposed angle, by construction. But $\angle ADC =$ distance of P and G . (413)

Therefore the $\angle ADC$ is the angle required.

459. *When the required circle is to make a given angle with the primitive.*

Then, From the centre of the primitive, with the tang. of the given angle, describe an arc; and from the given point A , with the secant of the given angle, cut the former arc.

On this intersection, a circle being described thro' the given point A , will cut the primitive circle in the angle proposed.

This depends on art. 451.

460.

PROBLEM XI.

Any great circle, cutting the primitive, being given; to describe another great circle, which shall cut the given one in a proposed angle, and have a given arc intercepted between the primitive and given circles.

Let ABC be the primitive circle whose centre is P ; and the given great circle be ADC whose centre is E .

SOLUTION. Draw a diameter EBD at right angles to ADC ; and make the angle BDF equal to the complement of the given angle; suppose $=$ comp. of 35° . (175)

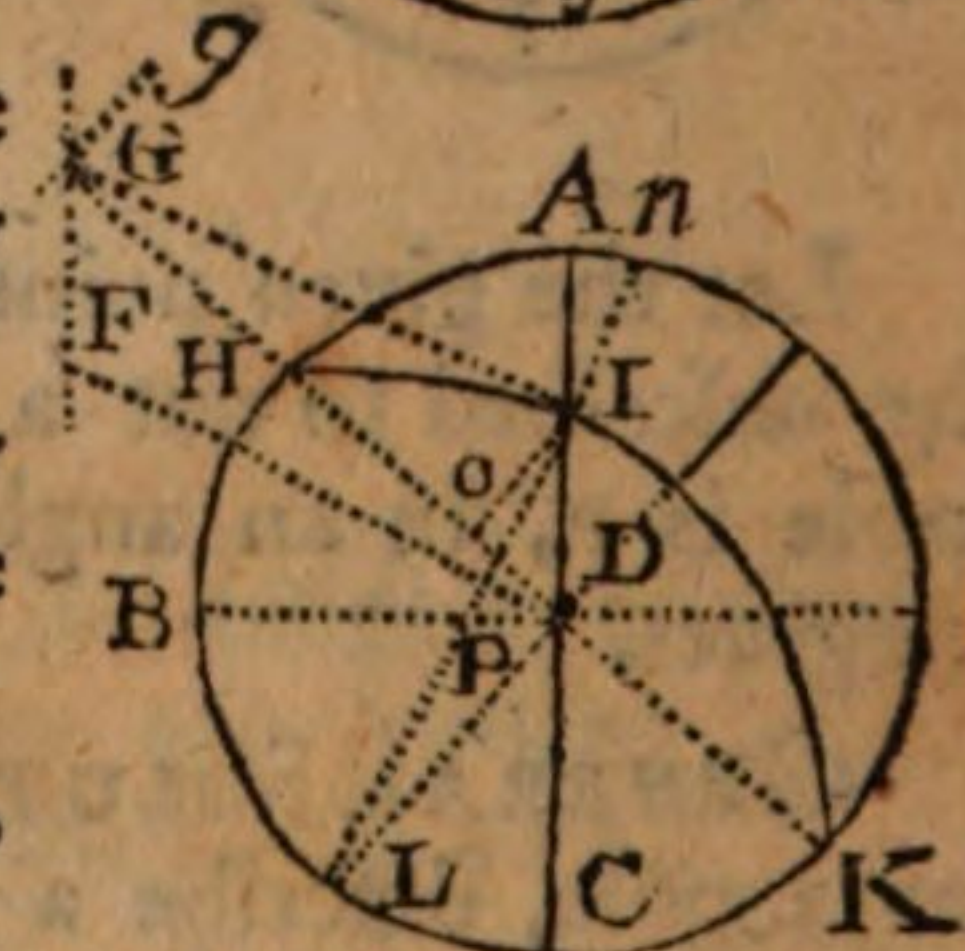
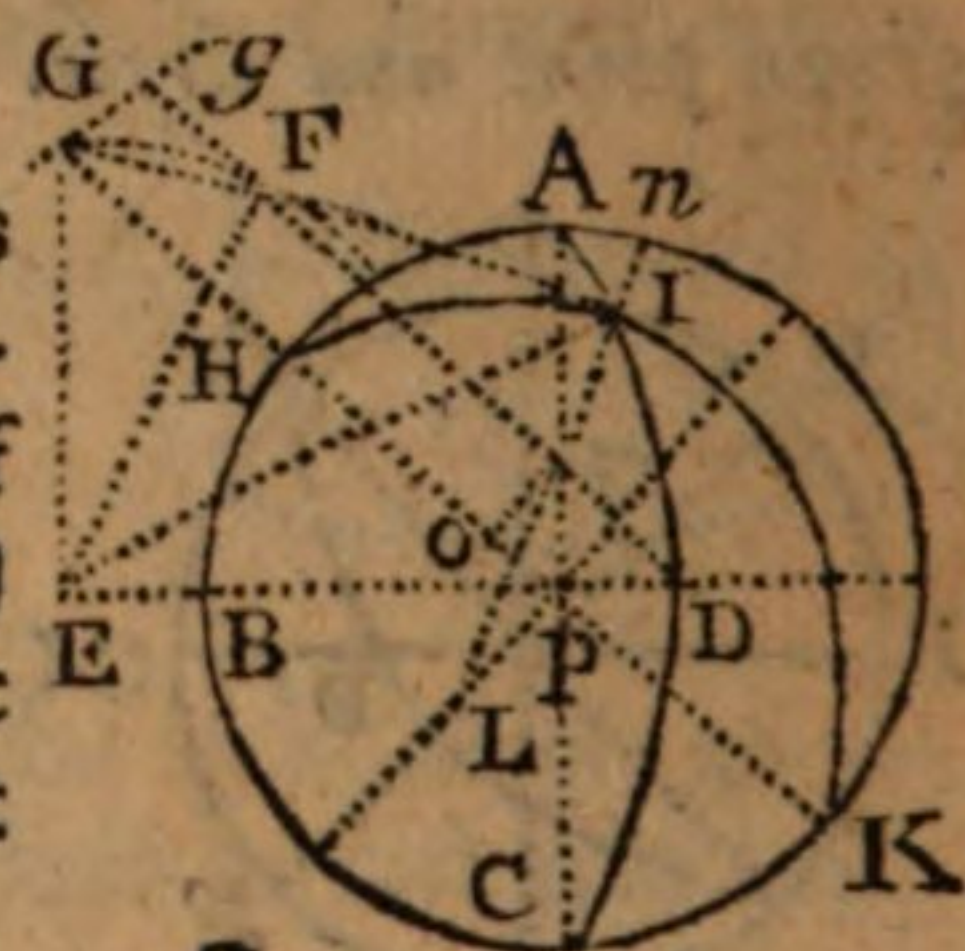
Make DF equal to the tangent of the given arc (suppose 58°); and from P with the secant of that arc, describe an arc Gg .

Now when ADC is an oblique circle; From E the centre of ADC , with the radius EF , cut the arc Gg in G .

But when ADC is a right circle; Thro' F draw FG parallel to ADC cutting the arc Gg in G : The centre E of ADC being vastly distant.

From G , with the tangent DF , describe an arc no , cutting ADC in I ; and draw GI .

Thro' G and the centre P draw GK , cutting the primitive circle in H, K ; draw PL perpendicular to GK ; and IL at right angles to IG , cutting PL in L .



And

And L will be the centre of a circle passing thro' H, I, K , which will be the great circle required.

Then the $\angle AIH = 35^\circ$; and arc $IH = 58^\circ$, as was proposed.

For GP is the secant, and GI is the tang. of the arc HI . (439)

And as the triangles EGI, EFD , are congruous; the $\angle EIG = \angle EDF$. (191)

But the $\angle EIG$ made by the tangent of the arc HI and the radius of arc AI , is the complement of the angle made by those arcs. (429)

Consequently the $\angle AIH$ is the complement of $\angle EDF$.

461.

P R O B L E M XII.

Any great circle in the plane of projection being given; to describe another great circle, which shall make given angles with the primitive and given circles.

Let the given great circle be ADC , whose pole is Q .

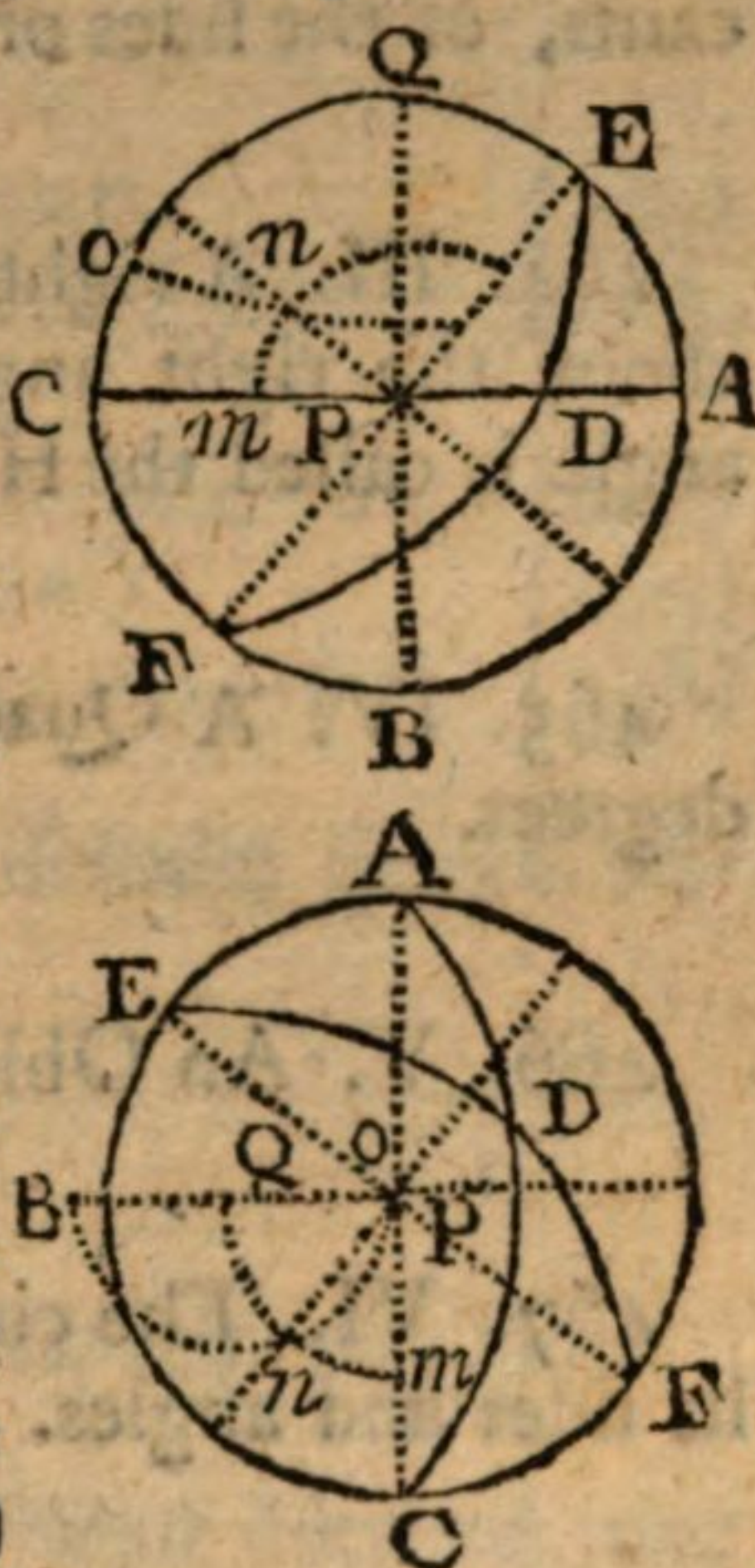
SOLUTION. About P the pole of the primitive circle, describe an arc mn , at the distance of as many degrees, as are in the angle which the required circle is to make with the primitive. Suppose 62° . (455)

About Q the pole of the other given circle, and at a distance equal to the measure of the angle which the required circle is to make with the given circle ADC (suppose 48°), describe an arc on , cutting mn in n . (456)

About n as a pole, describe the great circle EDF , cutting the given circles in E and D . (442)

Then is the angle $AED = 62^\circ$; and $\angle ADE = 48^\circ$.

For the distance of the poles of any two great circles, is equal to the angle which those circles make with one another. (413)



SECTION IV.

SPHERICAL TRIGONOMETRY.

Definitions and Principles.

462. I. Spheric Trigonometry is the art of computing the measures of the sides and angles of such triangles as are formed on the surface of a sphere, by the mutual intersections of three great circles described thereon.

463. II. A spheric triangle consists of three sides and three angles.

The measures of unknown sides or angles of spheric triangles, are estimated by the relations between the sines, or the tangents, or the secants, of the sides or angles known, and of those that are unknown.

464. III. A right angled spheric triangle has one right angle: The sides about the right angle are called Legs; and the side opposite to the right angle is called the Hypothenuse.

465. IV. A Quadrantal spheric triangle has one side equal to ninety degrees.

466. V. An Oblique spheric triangle has all its angles oblique.

467. VI. The circular parts of a triangle, are the arcs which measure its sides and angles.

468. VII. Two spheric triangles are said to be supplements to one another, when the sides and angles of the one are respective supplements of the angles and sides of the other: And one, in regard to the other, is called the supplemental triangle.

469. VIII. Two arcs or angles, when compared together, are said to be alike, or of the same kind, when both are acute, or less than 90° , or when both are obtuse, or greater than 90° : But when one is greater and the other less than 90° , they are said to be unlike.

The lesser circles of the sphere do not enter into Trigonometrical computations, because of the diversity of their radii.

SECTION V.
 SPHERICAL THEOREMS.

470.

THEOREM I.

In every spheric triangle (ABC), equal angles (B, C) are opposite to equal sides (AC, AB): And equal sides (AB, AC) are opposite to equal angles (C, B).

DEM. Since $AB = AC$, make $AE = AD$; and draw BD, CE .

Then is $BD = CE$; and $\angle AEC = \angle ADB$. (407)

For the triangles AEC, ADB , are congruous,

Since $AB = AC$; $AD = AE$; $\angle A$ common.

Also, the triangles BEC, CDB , are congruous (407).

Therefore $\angle EBC = \angle DCB$.

For $EC = BD$; $EB = (AB - AE =) DC (= AC - AD)$.

And $\angle BEC = (\text{sup. } \angle AEC =) \angle CDB (= \text{sup. } \angle ADB)$.

AGAIN, if $\angle ABC = \angle ACB$: Then is $AB = AC$.

For take $BE = CD$; and describe the arcs CE, BD .

Then is $EC = DB$; $\angle BEC = \angle CDB$; $\angle BCE = \angle CBD$. (407)

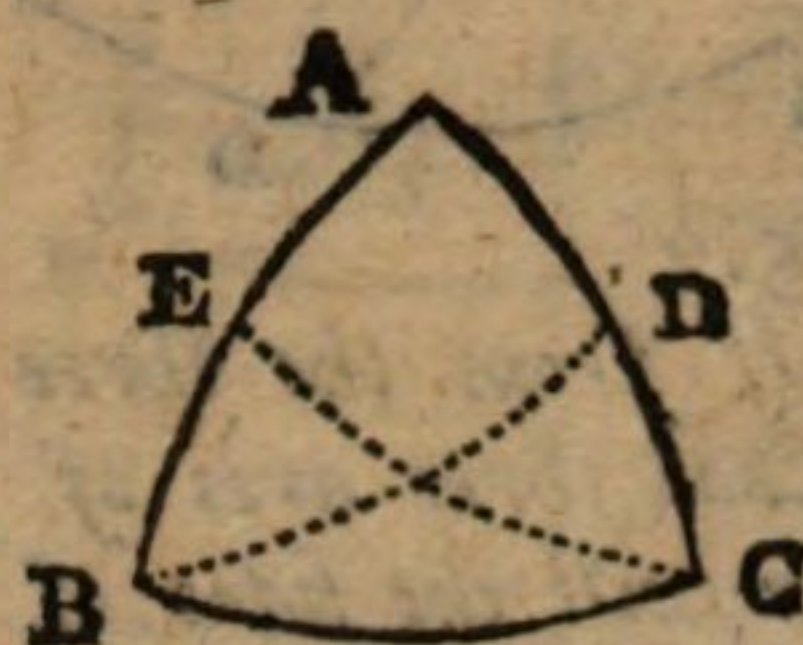
For $\triangle BCE = \triangle CBD$; since BC is common, $BE = CD$, $\angle EBC = \angle DCB$.

Also the triangles ABD, ACE , are congruous.

Since $EC = BD$, $\angle ACE = (\angle BCA - BCE =) (139) \angle ABD (= \angle CBA - CBD)$.

And $\angle AEC = (\text{sup. } \angle BEC =) \angle ADB (= \text{sup. } \angle CDB)$. (139)

Therefore $AE = AD$; and $AB = (AE + EB =) AC (= AD + DC)$. (138)



471. COR. A line drawn from the vertex of an isosceles spheric triangle perpendicular to the base, will bisect that base.

This is easily proved from art. 470, 407.

472.

THEOREM II.

Either side of a spheric triangle is less than the sum of the other two sides.

DEM. For on the surface of a sphere, the shortest distance between two points, is an arc of a great circle passing thro' those points. (404)

But each side of a spheric triangle is an arc of a great circle. (390)

Therefore either side being the shortest distance between its extremities, is less than the sum of the other two sides.

473.

THEOREM III.

Each side of a spheric triangle is less than a semicircle, or 180 degrees.

DEM. Two great circles intersect each other twice at the distance of 180 degrees. (412)

The sides about any spheric angle are the arcs of two great circles. (390)

But a spheric triangle has three sides.

Therefore every two sides before their second meeting must be intersected by the third side.

Consequently each side is less than a semicircle.

¶ The mark $\triangle$ stands for the word triangle.

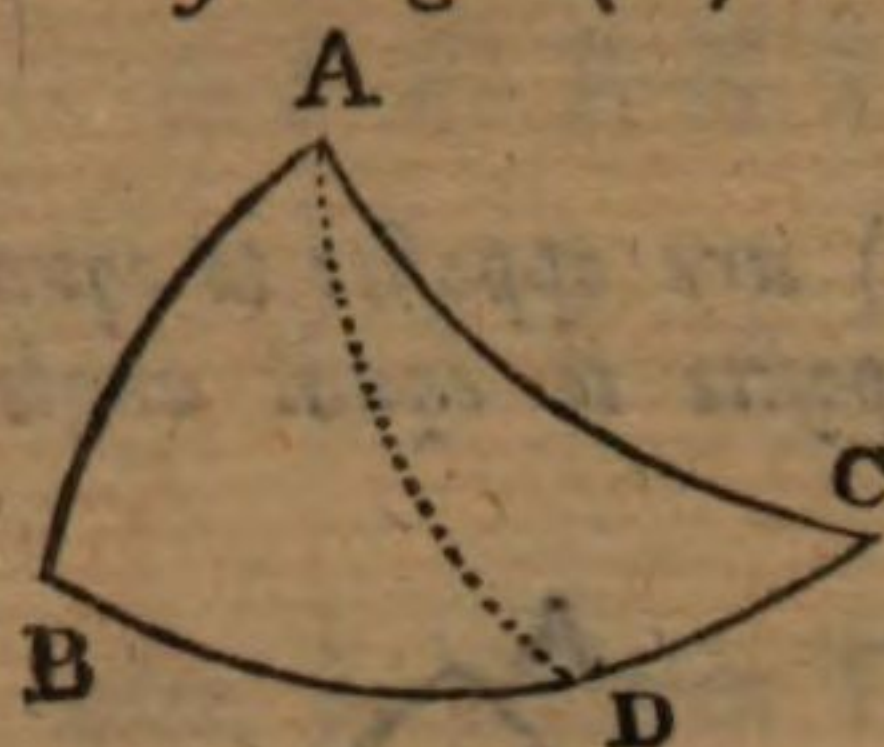
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474.

474.

THEOREM IV.

In every spheric triangle (ABC) the greatest side (BC) is opposite to the greatest angle (A).



DEM. Make $\angle BAD = \angle ABC$.

Then $AD = BD$ (470); and $BC = AD + DC$.

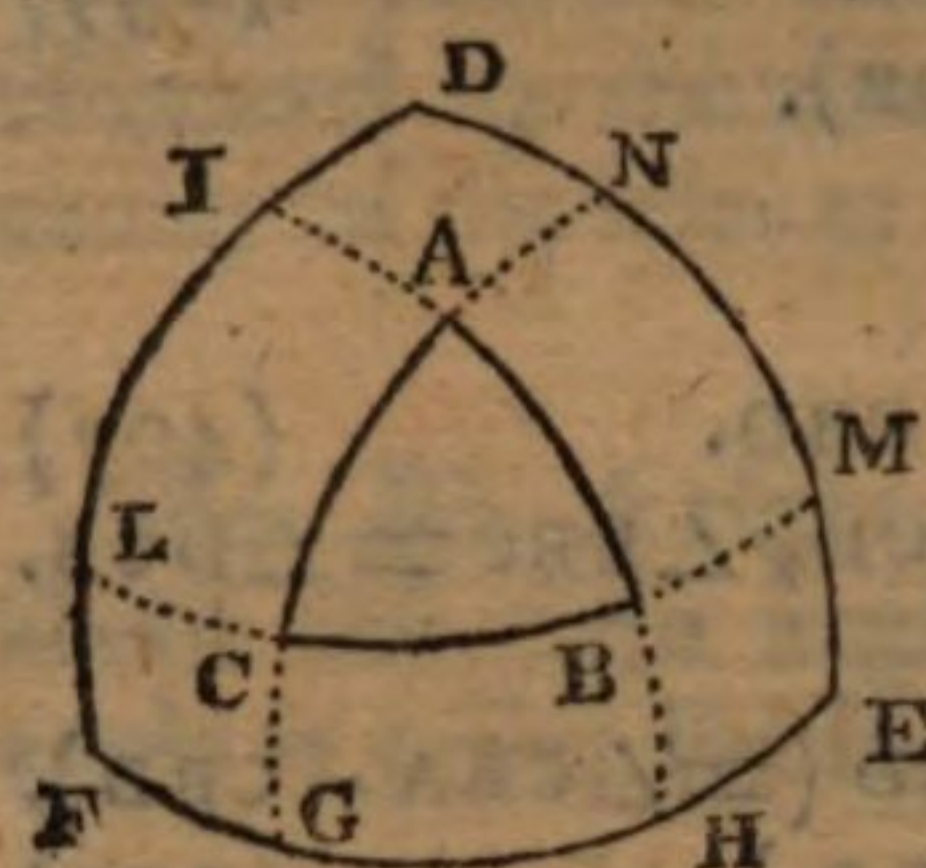
But $AD + DC$ is greater than AC .

Therefore BC is greater than AC . (472)

475.

THEOREM V.

If from the three angles of a spheric triangle (ABC), as poles, be described three arcs of great circles, forming another spheric triangle (EDF); then will the sides of the latter, and the opposite angles of the former, be the supplements of one another: Also the angles in the latter, and their opposite sides in the former, are the supplements of one another.



That is, FE and $\angle CAB$, FD and $\angle ABC$, DE and $\angle ACB$, are supplements to one another.

Also $\angle E$ and AC , $\angle D$ and CB , $\angle F$ and AB , are the supplements to one another.

DEM. Now E , the intersections of the arcs about the poles A and C , being 90° distant from them, is the pole of the arc AC . (399)

And for the same reason, D is the pole of CB , and F of AB .

Let the sides of the triangle ABC be produced to meet the sides of the triangle DEF , in G and H , I and L , M and N .

Then $FI = DL = 90^\circ$: Therefore $(DL + FI = DL + FL + LI =) DF + LI = 180^\circ$.

Therefore DF and LI are supplements to one another.

But LI measures the angle ABC . (389)

Therefore $\angle ABC$ and DF are the supplements of one another.

And in the same manner it may be demonstrated, that the $\angle BAC$ and FE , $\angle ACB$ and DE , are the supplements of one another.

Again, since $BI = AH = 90$ degrees. (399)

Therefore $(IB + AH = IB + BH + AB =) IH + AB = 180$ degrees.

But IH measures the angle F . (389)

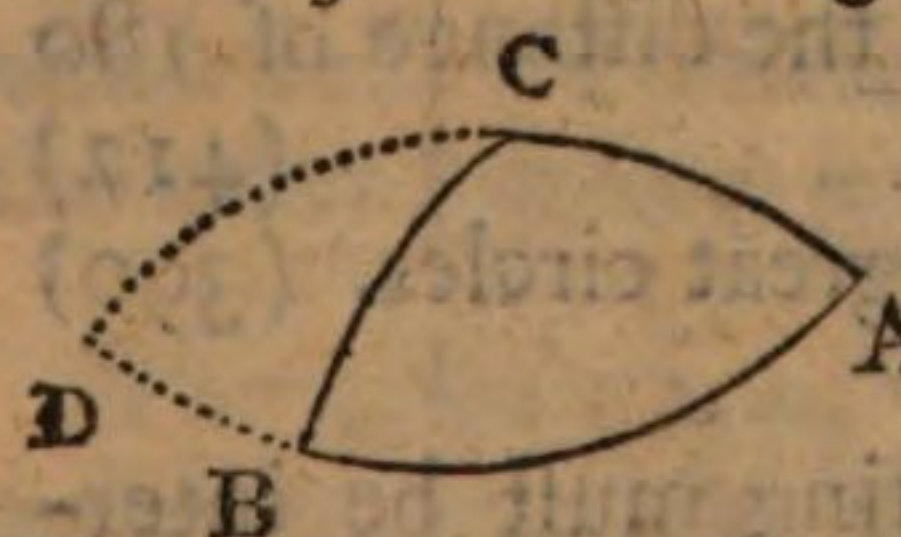
Therefore AB and $\angle F$ are the supplements of one another.

And the same may be shewn of AC and $\angle E$, CB and $\angle D$.

476.

THEOREM VI.

The sum of the three sides of every spheric triangle (ABC) is less than a circumference, or 360 degrees.



DEM. Continue the sides AC , AB , till they meet in D .

Then the arcs ACD , ABD , are each 180° . (412)

But $DC + DB$ is greater than BC (472)

Therefore $AC + AB + DC + DB$ is greater than $AC + AB + BC$.

Or the semicircles $ACD + ABD$ is greater than $AC + AB + BC$.

That is, 360° is greater than the three sides of the triangle ABC .

477.

477.

THEOREM VII.

The sum of the three angles of a spheric triangle (ABC) is greater than two right angles, and less than six; or will always fall between 180° and 540° degrees.

DEM. Since $\angle A$ and FE , $\angle B$ and FD , $\angle C$ and DE , are supplements to one another. (475)

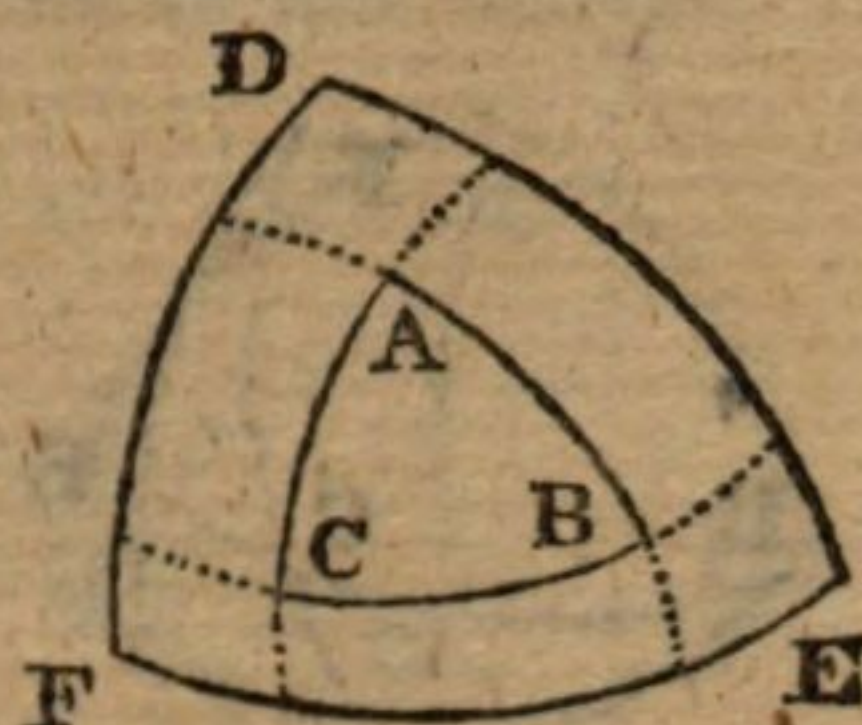
Therefore the three angles A, B, C , together with the three sides FE, FD, DE , make thrice 180° , or 540° .

Now the sum of the three sides $FE + FD + DE$ is less than twice 180° . (476)

Therefore the sum of the three angles $A + B + C$, is greater than 180° .

Again, As a spheric angle is ever less than 180° . (405)

Therefore the sum of any three spheric angles is ever less than thrice 180° , or 540° degrees.



478.

THEOREM VIII.

If one side (AB) of a spheric triangle (ABC) be produced, then the outward angle (CBD) is either equal to, less, or greater than, the inward opposite angle (A) adjacent to that side; according as the sum of the other two sides ($CA + CB$) is equal to, greater, or less than, 180° degrees.

DEM. Produce AC, AB, to meet in D.

Then $ACD = ABD = 180^\circ$ (412). And $\angle D = \angle A$. (411)

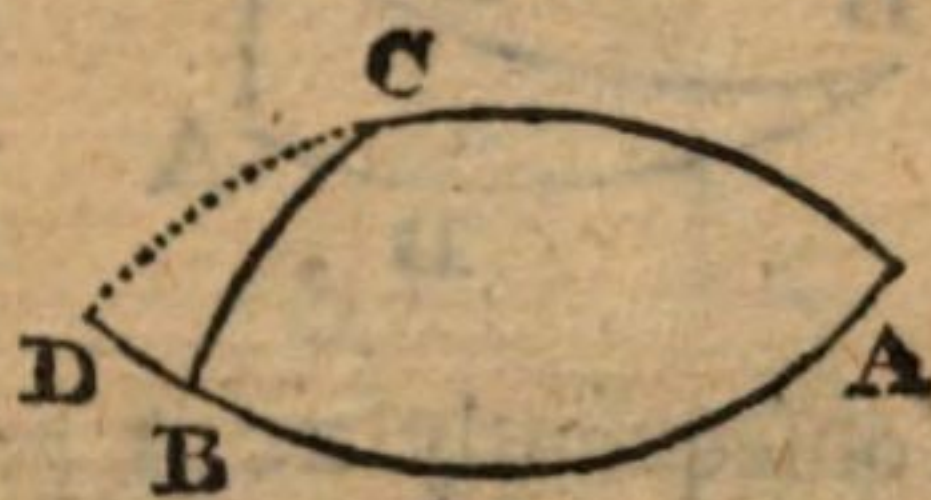
Now if $AC + CB$ is equal to 180° ; then $CB = CD$. And $\angle CBD = (\angle D =) \angle A$. (470)

If $AC + CB$ is greater than 180° ; then CB is greater than CD .

And $\angle CBD$ is less than $(\angle D =) \angle A$. (474)

If $AC + CB$ is less than 180° ; then CB is less than CD .

And $\angle CBD$ is greater than $(\angle D =) \angle A$. (474)



479.

THEOREM IX.

In right angled spheric triangles, the oblique angles and their opposite sides are of the same kind: That is, if a leg is less or greater than 90° , its opposite angle is also less or greater than 90° .

In the right angled spheric triangle ABC, right angled at A.

If AC is greater than 90° ; then $\angle ABC$ is greater than 90° .

If AC is less than 90° ; then $\angle ABC$ is less than 90° .

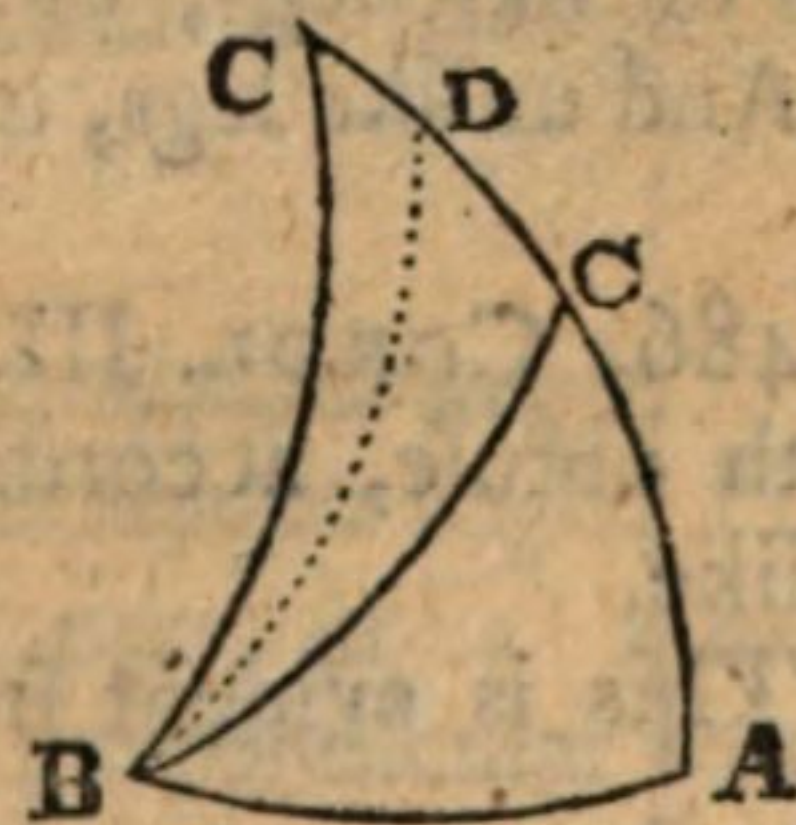
DEM. Let the leg AC be less, AD equal, AC greater, than 90° , and describe the arc DB.

Now D being the pole of AB (417). Therefore $\angle DBA$ is right.

Consequently if AC is less than AD, the $\angle CBA$ is less than $\angle DBA$.

But if AC is greater than AD, the $\angle CBA$ is greater than $\angle DBA$.

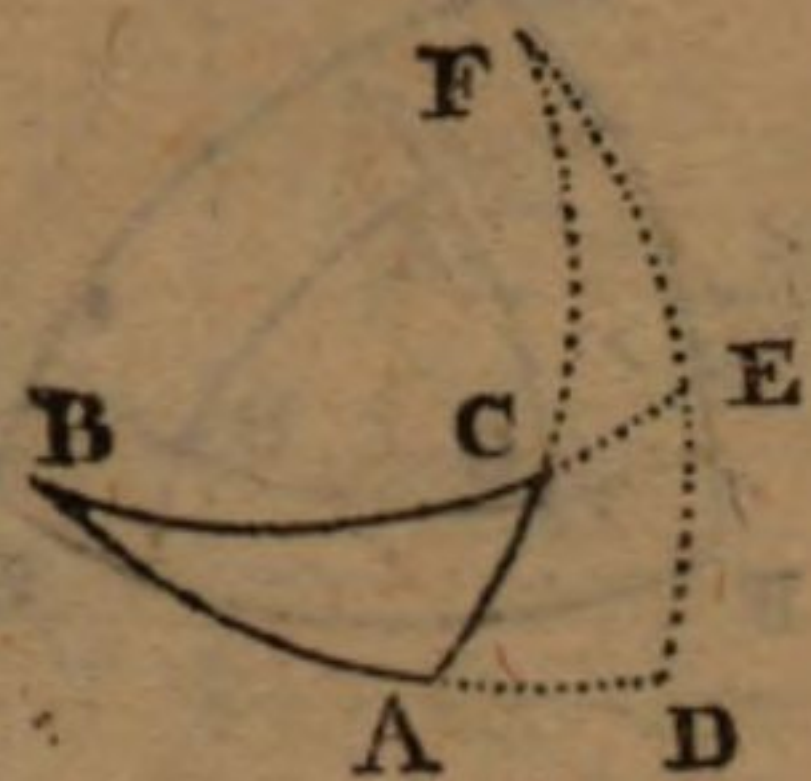
And the same may be proved of the leg AB and its opposite angle.



480.

THEOREM X.

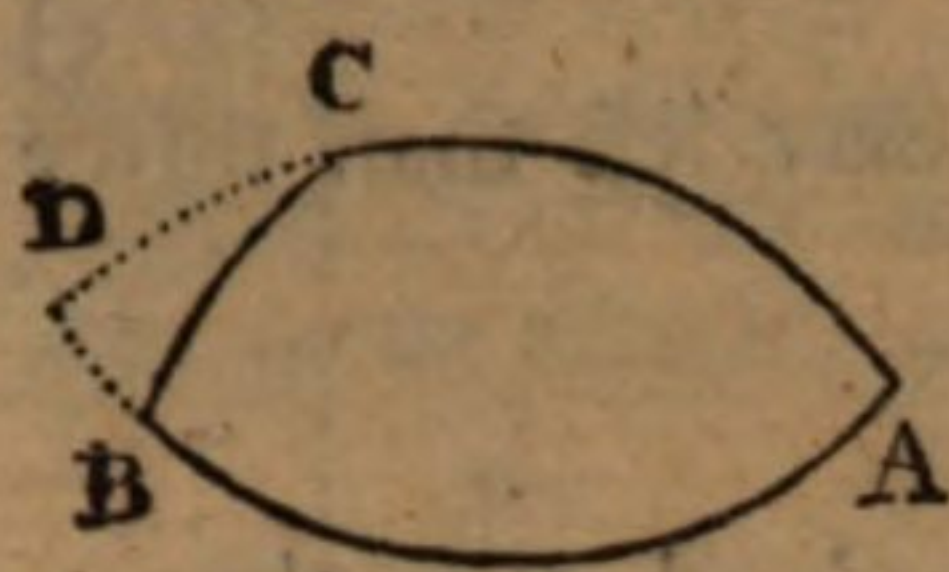
In right angled spheric triangles (BAC), the hypotenuse (BC) is less than 90° when the legs (AB, AC) are of a like kind: But the hypotenuse is greater than 90° , when the legs are of different kinds.



481. When the legs AB, AC, are both less than 90° .
DEM. In BA, AC produced, take BD, AF, equal to quadrants; thro' F and D describe an arc FD meeting BC produced in E.

Now F being the pole of BD (399). Therefore B is the pole of FD.

Consequently BC is less than $(BE =) 90^\circ$.



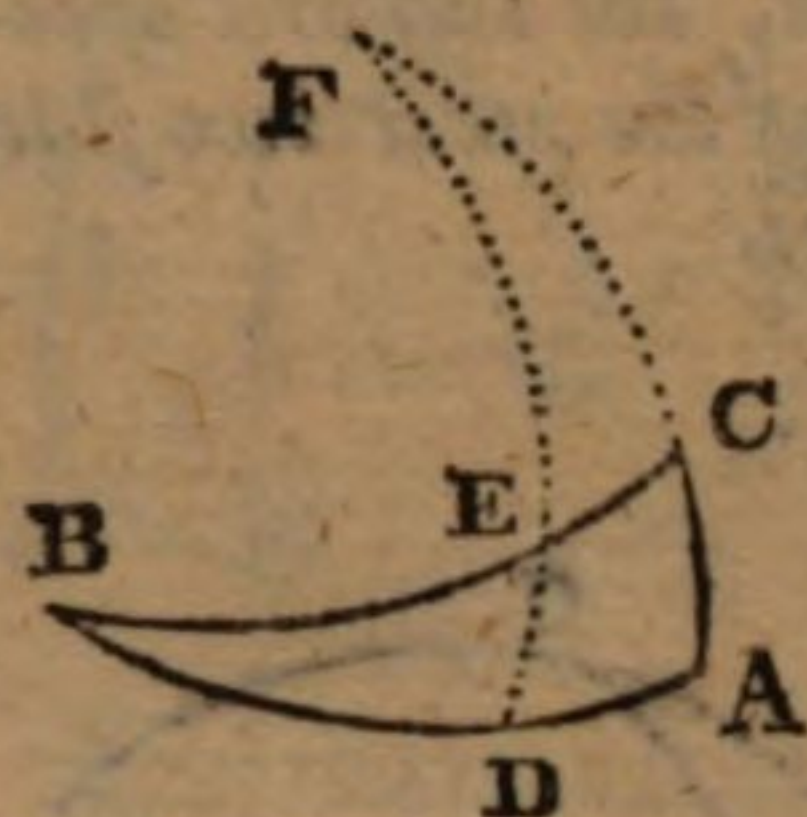
482. When the legs AB, AC, are both greater than 90° .

Produce AC, AB, till they meet in D.

Now the hypotenuse CB is common to both the right angled triangles BAC and BDC.

And the legs DC, DB, being both less than 90° .

Therefore the hypotenuse BC is less than 90° , by art. 481.



483. When the legs AB, AC, are one greater, the other less than 90° .

In AB, and AC produced, take BD, AF, each of 90° , and describe the arc FED.

Then B is the pole of FD; since F is the pole of BA, and FD is at right angles to BD. Theref. $BE = 90^\circ$.

(417)

Consequently BC is greater than 90 degrees.

484. COROL. I. The hypotenuse is less or greater than 90° , according as the oblique angles are of a like, or of different kinds.

For if legs are like, or unlike, the angles are like, or unlike. (479)

And if legs are like, or unlike, the hypoth. is acute, or obtuse. (480)

Therefore if the angles are like, or unlike, the hypotenuse is acute, or obtuse.

485. COROL. II. The legs and their adjacent angles are like, or unlike, as the hypotenuse is less or greater than 90 degrees.

For like legs, or like angles, make the hypoth. acute. (481, 482)

And unlike legs, or unlike angles, make the hypoth. obtuse. (483, 484)

486. COROL. III. A leg and its opposite angle are both acute, or both obtuse, according as the hypotenuse and other leg are like, or unlike.

This is evident from the three cases of this Theorem.

487. COROL. IV. Either angle is acute, or obtuse, as the hypotenuse and the other angle are like, or unlike.

This follows from art. 481, 482.

488. THEOREM XI.

In every spheric triangle (ABC), if the angles adjacent to either side (AB) be alike, then a perpendicular (CD) drawn to that side from the other angle, will fall within the triangle: But the perpendicular (CD) falls without the triangle, when the angles adjacent to the side (AB) it falls on are unlike.

DEMONST. Since in all right angled triangles the perpendicular and its opposite angle are of the same kind. (479)

Therefore the $\angle CAD$ and CBD , are each like CD .

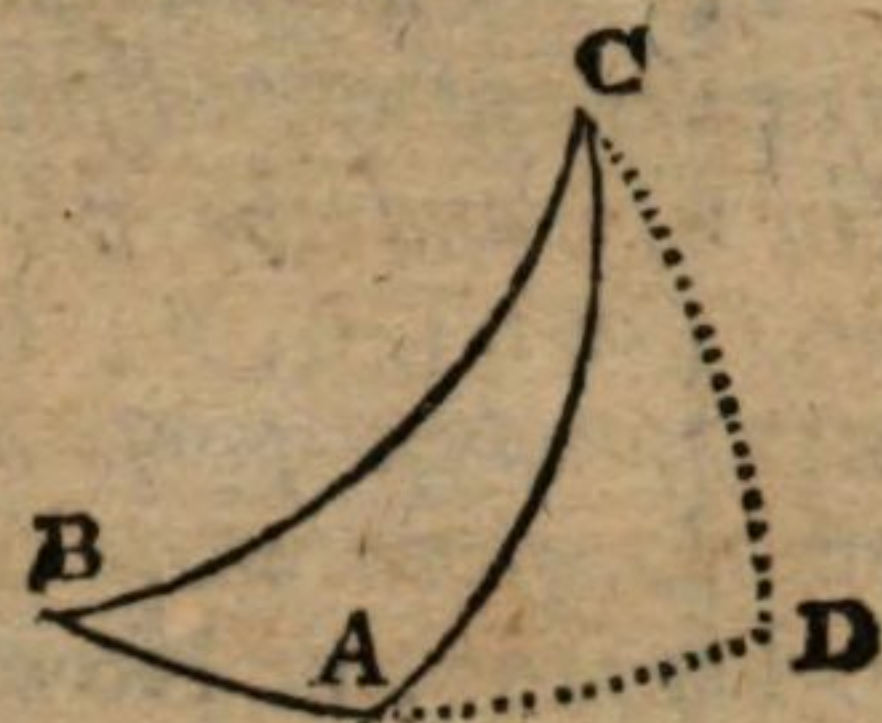
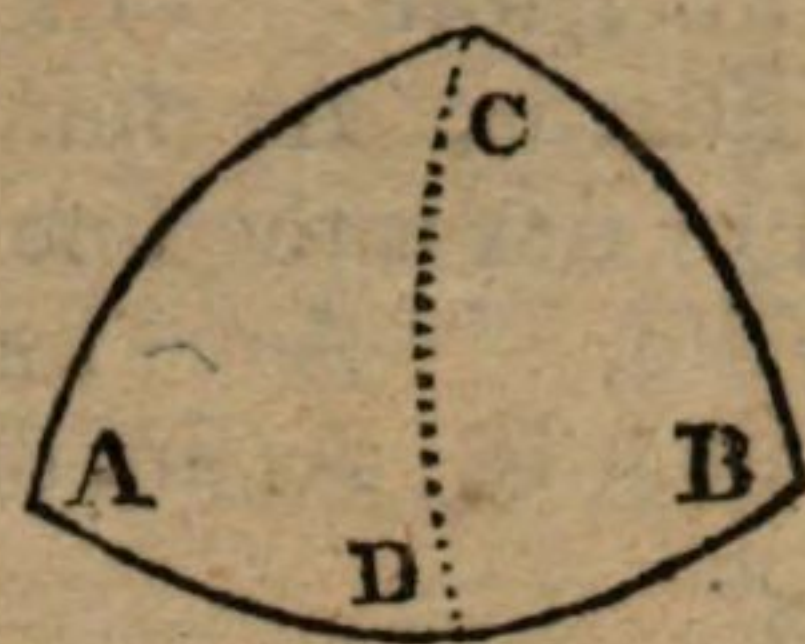
Now in Fig. 1. the angles CAD , CBD , or CAB , CBA , are angles adjacent to the base AB within the triangle, and are alike.

Therefore the perpendicular falling between A and B , falls within the triangle.

In Fig. 2. the angles CAD and CAB are the supplements of each other, and are therefore unlike, as CA falls obliquely on AB .

Therefore $\angle CAB$ is unlike to $\angle CBA$.

Consequently the perpendicular CD cannot fall between A and B : Therefore it must fall without.



489. THEOREM XII.

If the two lesser sides (CA, CB) of a spheric triangle (ABC) are of the same kind; then an arc (CD) drawn from their included angle (ACB) perpendicular to the opposite side (AB), will fall within the triangle.

DEMONST. In AB take $AF = AC$; draw CF , and AH at right angles to CF .

Then $CH = HF$ (471) are each less than 90° . (473)

Also take $BE = BC$; draw CE , and BG at right angles to CE .

Then $CG = GE$ (471) are each less than 90° . (473)

Now in the right angled triangles FHA , EGB ; if the hypotenuses $AF (= AC)$, and $BE (= BC)$ are acute, or like FH and EG ;

Then the angles AFH and BEG are acute, and like AC and BC ; (486)

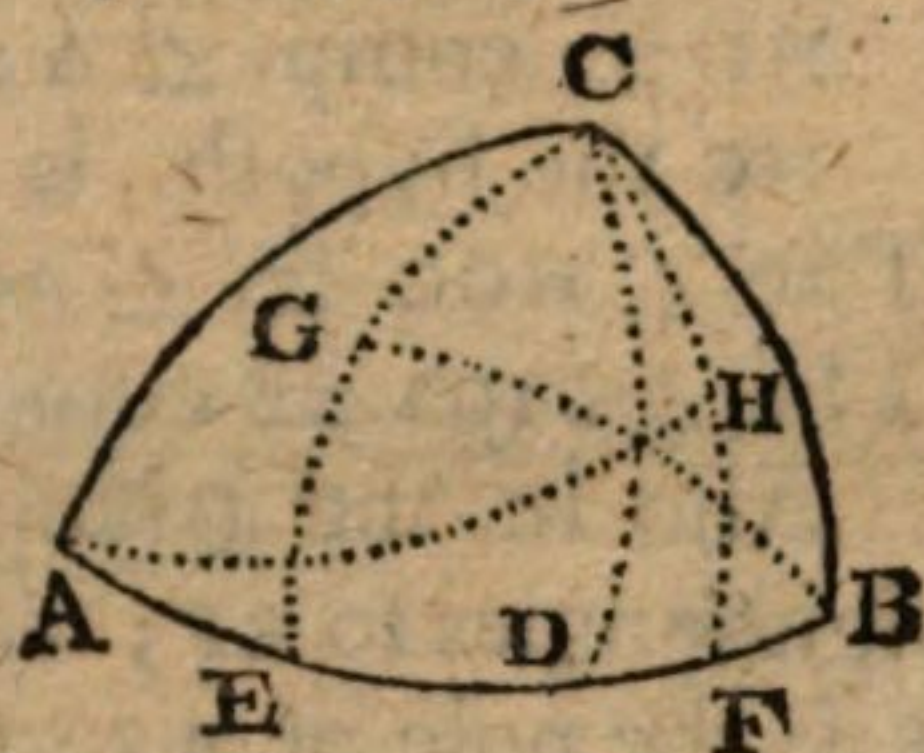
Therefore the perpendicular CD falls on EF , within the triangle. (488)

Also, if the hypotenuses AF and BE are obtuse, or unlike to FH and GE ;

Then the angles AFH and BEG are obtuse, and also like CA and CB . (486)

Consequently the perpendicular will fall on EF . (488)

Therefore in either case the perpendicular falls within the triangle.



490. THEOREM XIII.

In all right angled spheric triangles.

As sine hypoth. : Rad :: sine of a leg : sine of its opposite angle.

491. *And sine a leg : Rad :: tan. other leg : tan. of its opposite angle. Pl. I.*

DEMONST. Let $EDAFG$ represent the eighth part of a sphere, where the quadrantal planes $EDFG$, $EDBC$, are both perpendicular to the quadrantal plane $ADFB$; and the quadrantal plane $ADGC$ is perpendicular to the quadrantal plane $EDFG$; and the spheric triangle ABC is right angled at B , where CA is the hypotenuse, and BA , BC , are the legs.

To the arcs GF , CB , draw the tangents HF , OB , and the sines GM , CI , on the radii DF , DB ; also draw BL the sine of the arc AB , and CK the sine of AC ; then join IK and OL .

Nw

Now HF, OB, GM, CI, are all perpendicular to the plane ADFB.

And HD, GK, OL, lie all in the same plane ADGC.

Also FD, IK, BL, lie all in the same plane ADGC.

Therefore the right angled triangles HFD, CIK, OBL, having the equal angles HDF, CKI, OLB, (273) are similar. (250)

Therefore $CK : DG :: CI : GM$

That is, As fin. hyp. : Rad :: fin. of a leg : fin. opp. angle.

For GM is the sine of the arc GF, which measures the angle CAB. (389)

Also, As LB : DF :: BO : FH

That is, As fin. of a leg : Rad :: tan. of other leg : tan. opp. angle.

492.

THEOREM XIV.

In right angled spheric triangles (ABC) if about the oblique angles (A, C) as poles, at 90° distance, there be described arcs (DE, FE) cutting one another (in E); and the sides (AB, AC, BC) of the triangle be produced to cut those arcs (in D; G, F; H, I), there will be constituted two other triangles (CGH, HIE), whose parts are either equal to, or are the complements of the parts of the given one. Pl. I.

DEMONST. Now since A is the pole of ED (399). Therefore AD, AG are at right angles to ED; and so is ED to AD. (417)

And since BI and DE are at right angles to AD, their intersection H is the pole of AD (416). Therefore HB, HD, are quadrants. (415)

Then in the triangle CGH, right angled at G.

CG = complement of AC.

HG = comp. $\angle A$; For HG is the comp. of GD, which (389) meas. $\angle A$.

HC the hypoth. is the comp. of CB.

The $\angle HCG = \angle ACB$. (406)

The $\angle CHG = \text{comp. } AB$; For BD the comp. of AB, measures $\angle CHG$.

Also in the triangle EIH, right angled at I: Because CF, CI are at right angles to EF; and EF, EG being also at right angles to AF; therefore E is the pole of AF; (416) consequently EF and EG are quadrants (415)

Then the hypoth. EH = $\angle A$; For GH = comp. of EH and GD; and GD measures the angle A.

HI = CB; For HC = comp. of HI and CB.

EI = comp. $\angle C$; For EI = comp. of IF, which measures $\angle C$.

The $\angle H = \text{comp. } AB$; For BD, the comp. of AB, measures $\angle H$.

The $\angle E = AC$; For GF, the measure of $\angle E$, is equal to AC.

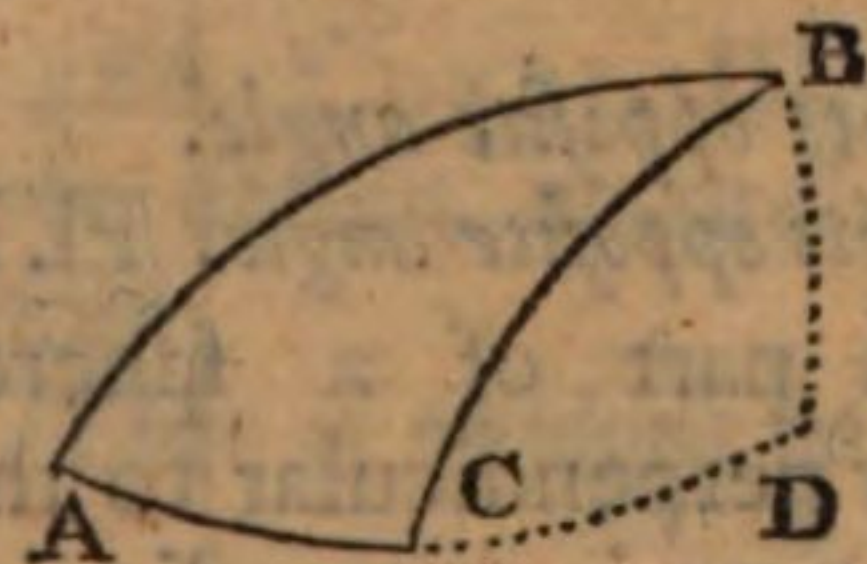
493.

THEOREM XV.

In every spheric triangle, it will be.

As the sine of either angle, is to the sine of its opposite side;

So is the sine of another angle, to the sine of its opposite side.



Let ABC be a spheric triangle, wherein BD is perpendicular to AC produced; forming the two right angled triangles ADB, CDB.

DEM. Now fin. AB : rad :: fin. BD : fin. $\angle A$. (490)

And fin. BC : rad :: fin. BD : fin. $\angle C$.

Therefore fin. AB $\times$ fin. $\angle A = \text{rad} \times \text{fin. } BD$. (245)

And fin. BC $\times$ fin. $\angle C = \text{rad} \times \text{fin. } BD$. (245)

Therefore fin. AB $\times$ fin. $\angle A = \text{fin. } BC \times \text{fin. } \angle C$. (137)

Therefore fin. $\angle A : \text{fin. } BC :: \text{fin. } \angle C : \text{fin. } AB$. (246)

SECTION

S E C T I O N VI.

Of the solution of right angled spheric triangles.

In every case of right angled spheric triangles, three things beside the radius enter the proportion, whereof two are given, and the third is sought.

Now the solution of every case will be obtained by the application of the two following rules to Theorem XIII and XIV. (490, 491, 492)

494. RULE I. If of the three things concerned, or their complements, two are opposite to one another, and the third is opposite to the right angle, in one of the triangles marked 1, 2, 3, in the fig. to Theo. XIV. Pl. I. Then the thing sought will be found by the first proportion (490) either directly, or by inversion.

495. RULE II. If of the three things concerned, or their complements, two are legs, and the third is an oblique angle, in either of the three triangles marked 1, 2, 3, in fig. to Theo. XIV. Pl. I. Then the thing sought will be found by the second proportion (491), either directly, or by inversion.

496. P R O B L E M I.

In the right angled spheric triangle ABC, Plate I. Theorem XIV.

Given the hypotenuse AC
and one of the legs AB } Required the rest.

1st. *To find the angle ACB opposite the given leg AB.*

Here the things concerned are AC, $\angle B$, AB, $\angle C$; which are found in the triangle N° 1, to be opposite; and so fall under Rule I. (494)

Then $\sin. AC : \text{rad} :: \sin. AB : \sin. \angle ACB.$ (490)

Or $\sin. \text{hyp.} : \text{rad} :: \sin. g. \text{leg.} : \sin. \text{op. } \angle.$ Like the g. leg. (479)

2d. *To find the angle CAB adjacent to the given leg AB.*

Here the things concerned are AC, $\angle B$, AB, $\angle A$.

Now trying in the triangle N° 1, I find the things concerned will fall under neither of the Rules.

But trying in the triangle N° 2, the things concerned, or their complements, fall under Rule II. (495)

Then $\sin. HG : \text{rad} :: \tan. GC : \tan. \angle CHG.$ (491)

Or $\cos. \angle CAB : \text{rad} :: \cot. AC : \cot. AB.$

Or $\cos. \angle CAB : \cot. AC :: (\text{rad} : \cot. AB) :: \tan. AB : \text{rad.}$ (331)

Therefore $\text{rad} : \cot. \text{hyp.} :: \tan. g. \text{leg} : \cos. \text{adj. angle}$ (228)

Like, or unlike the giv. leg; as the hyp. is acute, or obtuse. (485)

3d. *To find the other leg BC.*

Here the things concerned are AC, $\angle B$, AB, BC; which in the triangle, N° 1, do not fall under either Rule: But in N° 2 they will be found to fall under the first Rule. (494)

Then $\sin. HC : \text{rad} :: \sin. CG : \sin. \angle CHG,$ (490)

Or $\cos. CB : \text{rad} :: \cos. AC : \cos. AB.$

Therefore $\cos. g. \text{leg} (AB) : \text{rad} :: \cos. \text{hyp.} (AC) : \cos. \text{req. leg.} (CB)$

And is acute, if hyp. and giv. leg are like: But obtuse if unlike. (486)

497.

PROBLEM II.

In the right angled spheric triangle ABC. Pl. I. Theo. XIV.

Given the hypotenuse AC
 And one of the oblique angles A } Required the rest.

1st. *To find the leg CB opposite the given angle A.*

In the triangle, N° 1, the things concerned fall under Rule I. (494)

Then $\text{rad} : \text{fin. AC} :: \text{fin. } \angle \text{CAB} : \text{fin. CB.}$ (490)Or $\text{rad} : \text{fin. hyp.} :: \text{fin. giv. angle} : \text{fin. opp. side.}$

And is like the given angle. (479)

2d. *To find the leg AB adjacent to the given angle A.*

In the triangles, N° 2 or 3, the things concerned fall under Rule II. (495)

Then $\text{fin. HG} : \text{rad} :: \text{tan. CG} : \text{tan. } \angle \text{CHG.}$ (491)Or $\text{cos. } \angle \text{BAC} : \text{rad} :: (\text{cot. AC} : \text{cot. AB} ::) \text{tan. AB} : \text{tan. AC.}$ (332)Therefore $\text{rad} : \text{tan. AC} :: \text{cos. } \angle \text{BAC} : \text{tan. AB.}$ (228)Or $\text{rad} : \text{tan. hyp.} :: \text{cos. giv. angle} : \text{tan. adjacent leg.}$

And is acute, if hyp. and giv. angl. are alike; but obtuse if unlike. (487)

3d. *To find the other angle ACB.*

In the triangle, N° 2, the things concerned fall under Rule II. (495)

Then $\text{fin. CG} : \text{rad} :: \text{tan. GH} : \text{tan. } \angle \text{HCG.}$ (491)Or $\text{cos. AC} : \text{rad} :: (\text{cot. } \angle \text{BAC} : \text{tan. } \angle \text{BCA} ::) \text{cot. } \angle \text{BCA} : \text{tan. } \angle \text{BAC.}$ (332)Therefore $\text{rad} : \text{tan. } \angle \text{BAC} :: \text{cos. AC} : \text{cot. } \angle \text{BCA.}$ (228)Or $\text{rad} : \text{cos. hypoth.} :: \text{tan. giv. ang.} : \text{cot. req. angle.}$

And is acute, if hyp. and giv. ang. are alike; but obtuse if unlike. (487)

498.

PROBLEM III.

In the right angled spheric triangle ABC. Pl. I. Theo. XIV.

Given one of the legs AB
 And is opposite angle ACB } Required the rest.

1st. *To find the hypotenuse AC.*

In the triangle, N° 1, the things concerned fall under Rule I. (494)

Then $\text{fin. } \angle \text{ACB} : \text{fin. AB} :: \text{rad} : \text{fin. AC.}$ (490)Or $\text{fin. giv. ang.} : \text{fin. giv. leg} :: \text{rad} : \text{fin. hyp.}$

And is either acute or obtuse.

2d. *To find the other leg CB.*

In the triangle, N° 1, the things concerned fall under Rule II. (495)

Then $\text{fin. CB} : (\text{rad} ::) \text{tan. AB} (: \text{tan. } \angle \text{ACB}) :: \text{cot. } \angle \text{ACB} : \text{rad.}$ (331)Or $\text{rad} : \text{cot. giv. ang.} :: \text{tan. giv. leg} : \text{fin. req. leg.}$

And is either acute or obtuse.

3d. *To find the other angle CAB.*

In the triangle, N° 3, the things concerned fall under Rule I. (494)

Then $\text{fin. EH} : \text{rad} :: \text{fin. EI} : \text{fin. } \angle \text{IHE.}$ (490)Or $\text{fin. } \angle \text{BAC} : \text{rad} :: \text{cos. } \angle \text{ACB} : \text{cos. AB.}$ Or $\text{cos. giv. leg} : \text{cos. giv. ang.} :: \text{rad} : \text{fin. required angle,}$

And is either acute or obtuse.

499.

PROBLEM IV.

In the right angled spheric triangle ABC. Plate I. Theorem XIV.

Given one of the legs AB
And its adjacent angle BAC } Required the rest.

1st. *To find the other angle BCA.*

In the triangle, N° 3, the things concerned fall under Rule I. (494)

Then $\text{rad} : \sin. EH :: \sin. \angle EHI : \sin. EI.$ (490)

Or $\text{rad} : \sin. \angle BAC :: \cos. AB : \cos. \angle ACB.$

Therefore $\text{rad} : \cos. \text{giv. leg} :: \sin. \text{giv. ang.} : \cos. \text{req. angle.}$

And is like the given leg. (479)

2d. *To find the other leg BC.*

In the triangle, N° 1, the things concerned fall under Rule II. (495)

Then $\sin. AB : \text{rad} :: \tan. BC : \tan. \angle CAB.$ (491)

Or $\text{rad} : \sin. AB :: \tan. \angle CAB : \tan. BC.$

Therefore $\text{rad} : \sin. \text{giv. leg} :: \tan. \text{giv. ang.} : \tan. \text{req. leg.}$

And is like the given angle. (479)

3d. *To find the hypotenuse AC.*

In the triangle, N° 2, the things concerned fall under Rule II. (495)

Then $\sin. GH : \text{rad} :: \tan. CG : \tan. \angle CHG.$ (491)

Or $\cos. \angle CAB : \text{rad} :: \cot. AC : \cot. AB.$

Therefore $\text{rad} : \cos. \text{giv. ang.} :: \cot. \text{giv. leg} : \cot. \text{hypotenuse.}$

And is acute, if the giv. leg and angle are alike; but obtuse if unlike. (485)

500.

PROBLEM V.

In the right angled spheric triangle ABC. Plate I. Theorem XIV.

Given both the legs AB, BC.

Required the rest.

1st. *To find either of the oblique angles, as BAC.*

In the triangle, N° 1, the things concerned fall under Rule II. (495)

Then, As $\sin. AB : \text{rad} :: \tan. BC : \tan. \angle BAC.$ (491)

Or $\text{rad} : \sin. AB :: (\tan. \angle BAC : \tan. BC ::) \cot. BC : \cot. \angle BAC.$ (332)

Therefore $\text{rad} : \sin. \text{one leg} :: \cot. \text{oth. leg.} : \cot. \text{opp. angle.}$

And is like its opposite leg. (479)

2d. *To find the hypotenuse AC.*

In the triangle, N° 2, the things concerned fall under Rule I. (494)

Then, As $\text{rad} : \sin. HC :: \sin. \angle CHG : \sin. CG.$ (490)

Or $\text{rad} : \cos. BC :: \cos. AB : \cos. AC.$

Therefore $\text{rad} : \cos. \text{one leg} :: \cos. \text{oth. leg} : \cos. \text{hypotenuse.}$

And is acute, if the legs are alike; but obtuse if unlike. (480)

501.

PROBLEM VI.

In the right angled spheric triangle ABC. Plate I. Theorem XIV.
Given both the angles BAC, BCA.
Required the rest.

1st. *To find either of the legs, as BC.*

In the triangle, N° 2 or 3, the things concerned fall under Rule I. (494)

Then $\text{rad} : \sin. HC :: \sin. \angle HCG : \sin. HG.$ (490)

Or $\text{rad} : \cos. BC :: \sin. \angle ACB : \cos. \angle BAC.$

Therefore sine of one angle : rad :: cos. oth. ang. : cos. opp. side.

And is like its opposite angle. (479)

2d. *To find the hypotenuse AC.*

In the triangle, N° 2, the things concerned fall under Rule II. (495)

Then, As $\sin. CG : \text{rad} :: \tan. GH : \tan. \angle HCG.$ (491)

Or $\cos. AC : (\text{rad} ::) \cot. \angle BAC (: \tan. \angle BCA) :: \cot. \angle BCA : \text{rad}.$ (331)

Therefore rad : cot. one angle :: cot. oth. ang. : cos. hypotenuse.

And is acute, if the angles are like. (484)

But obtuse if unlike.

In these six Problems are contained sixteen proportions, which are applicable to the like number of cases usually given to right angled spheric triangles; and these proportions being collected and disposed in a Table, will readily shew, by inspection, how any of the cases are to be solved.

The celebrated Lord NAPIER, the inventor of logarithms, contrived a general rule, easy to be remember'd, whereby the solution of every case in right angled spheric triangles is readily obtained, where the table of proportions is wanting; which rule is as follows.

GENERAL RULE.

502. *Radius multiplied by the sine of the middle part, is either equal to the product of the tangents of extremes conjunct.*

Or to the product of the cosines of extremes disjunct.

Observing ever to use the complements of the hypoth. and angles.

Lord Napier called the five parts of every right angled spheric triangle, omitting the right angle, circular parts; which he thus distinguished; the two legs, the complements of the two angles, and the complement of the hypotenuse; and any two of these circular parts being given, the others are to be found by this rule, as is shewn in what follows.

Now, In all the proportions about right angled spheric triangles, there are, besides the radius, three things concerned; one whereof may be called the middle term in respect of the other two; and these two, in respect to the middle term, may be called extremes.

When the two extremes are joined to the middle, they are called extremes conjunct: But when each of them are disjoined from the middle by an intermediate term (not concerned), they are then called extremes disjunct; taking notice that the right angle does not disjoin the legs.

These

These things duly observed, the practice of the Rule will appear in the following examples.

EXAMPLE I. *When the hypotenuse and the angles are concerned.*

The hypoth. is the middle term, and the two angles are extremes conjunct; then by the rule.

Rad $\times$ sin. hyp. = tan. one ang. $\times$ tan. other angle.

But the compl. of the hypoth. and angles are always to be used.

Therefore rad $\times$ cos. hyp. = cot. one ang. $\times$ cot. oth. angle.

Hence rad : cot. one ang. :: cot. oth. angle : cos. hypoth. (246)

From whence are deduced the 6th and 15th cases.

EXAM. II. *When the hypoth. and legs are under consideration.*

The hypoth. is the middle term, and the two legs are extremes disjunct, having the angles between them and the hypoth.

Then by the rule. Rad $\times$ sin. hyp. = cos. one leg $\times$ cos. oth. leg.

But the complement of the hypoth. is to be used.

Therefore rad $\times$ cos. hy. = cos. one leg $\times$ cos. oth. leg.

Hence rad : cos. one leg :: cos. oth. leg. : cos. hypoth. (246)

From whence are deduced the 3d and 13th cases.

EXAM. III. *The legs and an angle under consideration.*

Here one leg is the middle, and the angle and other leg are extremes conjunct :

And these being resolved into a proportion by the rule, will produce the 8th, 11th, and 14th cases.

EXAM. IV. *The angles and a leg under consideration.*

Here one angle is the middle, and the other angle and leg are extremes disjunct, the hypotenuse and other leg intervening.

Now these being resolved into a proportion, gives the 9th, 12th, and 16th cases.

EXAM. V. *The hypoth. a leg, and the angle between them being under consideration.*

Here the angle is the middle term, and the hypoth. and leg are extremes conjunct.

And these being resolved into a proportion, will give the 2d, 4th, and 10th cases.

EXAM. VI. *The hypotenuse, a leg and its opposite angle being under consideration.*

Here the leg is the middle term, and the hypotenuse and angle are extremes disjunct, the other leg and other angle falling between them and the middle.

And these being converted into a proportion, from thence the 1st, 5th, and 7th cases are deduced.

SECTION VII.

Of the solution of oblique angled spheric triangles.

503. All the cases in oblique angled spheric triangles, except where the three sides, or the three angles are given, are most conveniently resolved by drawing a perpendicular from one of the angles to its opposite side, continued if necessary; which perpendicular will either divide the given triangle into two right angled triangles, or make two that are right angled, by joining a right angled one to the given triangle.

In drawing of this perpendicular observe:

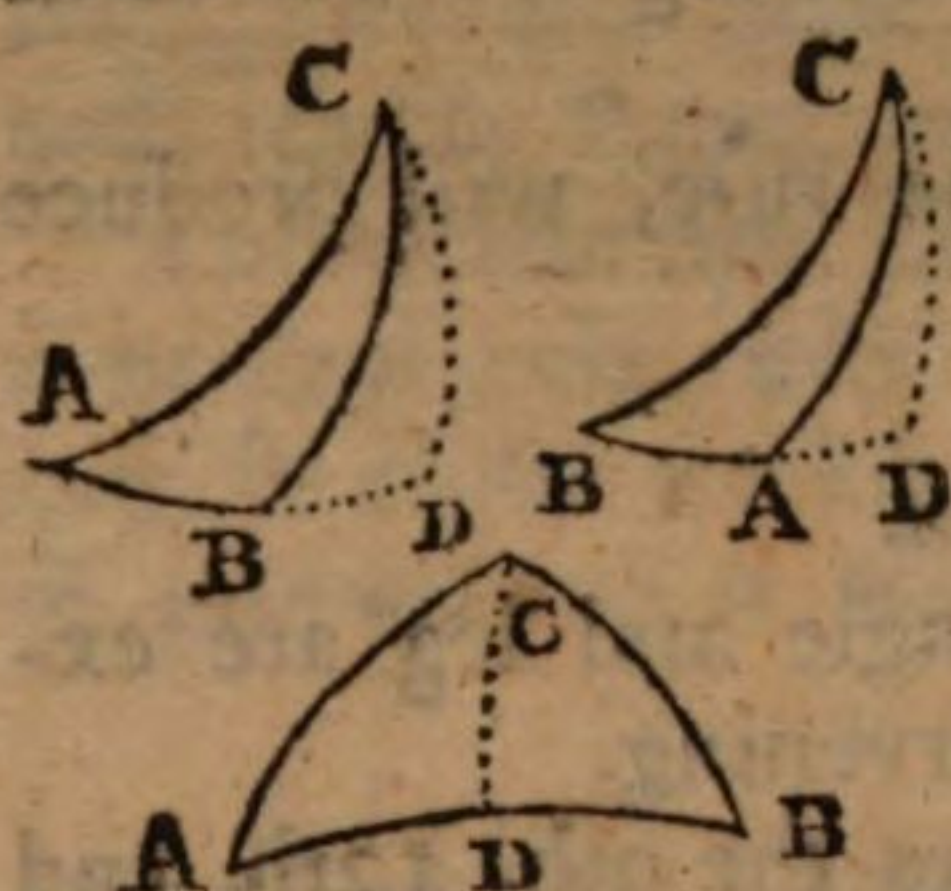
1st. It must be drawn from the end of a given side, and opposite to a given angle.

2d. It must be so drawn, that two of the given things in the oblique triangle may remain known in one of the right angled triangles.

3d. This perpendicular is to be used as a known quantity; and being drawn as here directed, will either fall within or without the triangle, as the angles, next the side on which it falls, are of the same or of different kinds. (488)

504.

PROBLEM I.



In the oblique angled spheric triangle ABC.

Given two sides CA, CB } Requir. the rest.
And the angle opp. to one, $\angle CAB$

1st. To find the angle opposite to the other given side ($\angle CBA$).

As $\sin. BC : \sin. \angle CAB :: \sin. AC : \sin. \angle CBA$. (493)

Or, As $\sin. one\ side : \sin. opp. ang. :: \sin. oth. side : \sin. opp. angle$.

Which may be either acute or obtuse.

2d. To find the angle between the given sides ($\angle ACB$).

Now $\text{rad} : \tan. \angle CAB :: \cos. AC : \cot. (ACD, \text{ call it } m)$. (3d. 497)

Or $\text{rad} : \tan. \text{giv. } \angle :: \cos. \text{adj. side} : \cot. (\text{of a fourth } =) m$.

And is acute, if AC and $\angle CAB$ are like: But obtuse if unlike.

But $\text{rad} : \tan. CD :: \cot. AC : \cos. (ACD =) m$. (2d. 496)

$\text{rad} : \tan. CD :: \cot. CB : \cos. (BCD, \text{ call it } n)$.

Therefore $\cot. AC : \cot. CB :: \cos. m : \cos. n$. (238)

Or $\cot. \text{side adj. giv. } \angle : \cot. \text{oth. side} :: \cos. m : \cos. n$.

And is like the side opposite the given angle, if that angle is acute;

But unlike that side, if the given angle is obtuse.

Then the angle sought, viz. $\angle ACB = \begin{cases} \text{sum of } m \text{ and } n, \text{ if } \perp^* \text{ falls within.} \\ \text{diff. of } m \text{ and } n, \text{ if } \perp \text{ falls without.} \end{cases}$

* The mark $\perp$ signifies the perpendicular.

3d. To

3d. To find the other side AB.

Now Rad : cos. $\angle CAB$:: tan. AC : tan. (AD, call it) M. (2d. 497)

Or Rad : cos. giv. ang. :: tan. adj. side : tan. (of a fourth =) M.

Acute, if the ang. and its adj. side are alike; but obtuse if unlike.

But cos. CD : Rad :: cos. AC : cos. (AD =) M.

cos. CD : Rad :: cos. CB : cos. (DB, call it) N. (3d. 496)

Therefore cos. AC : cos. CB :: cos. M : cos. N. (238)

Or cos. side adj. giv. ang. : cos. oth. side :: cos. M : cos. N.

Like the side opposite the given angle, if that angle be acute.

But unlike that side, if the angle be obtuse.

Then the side sought AB = $\begin{cases} \text{sum of M and N, if the } \perp \text{ falls within.} \\ \text{diff. of M and N, if the } \perp \text{ falls without.} \end{cases}$

But if CA = CB, or if CA = $180^\circ - CB$, or if CA is between BC and $180^\circ - BC$;

Then $\angle B$ is like BC only.

And if BC is $\begin{cases} \text{like } \angle A \\ \text{unlike } \angle A \end{cases}$; } Then $\angle ACB = m \pm n$ only; and AB = $M \pm N$ only.

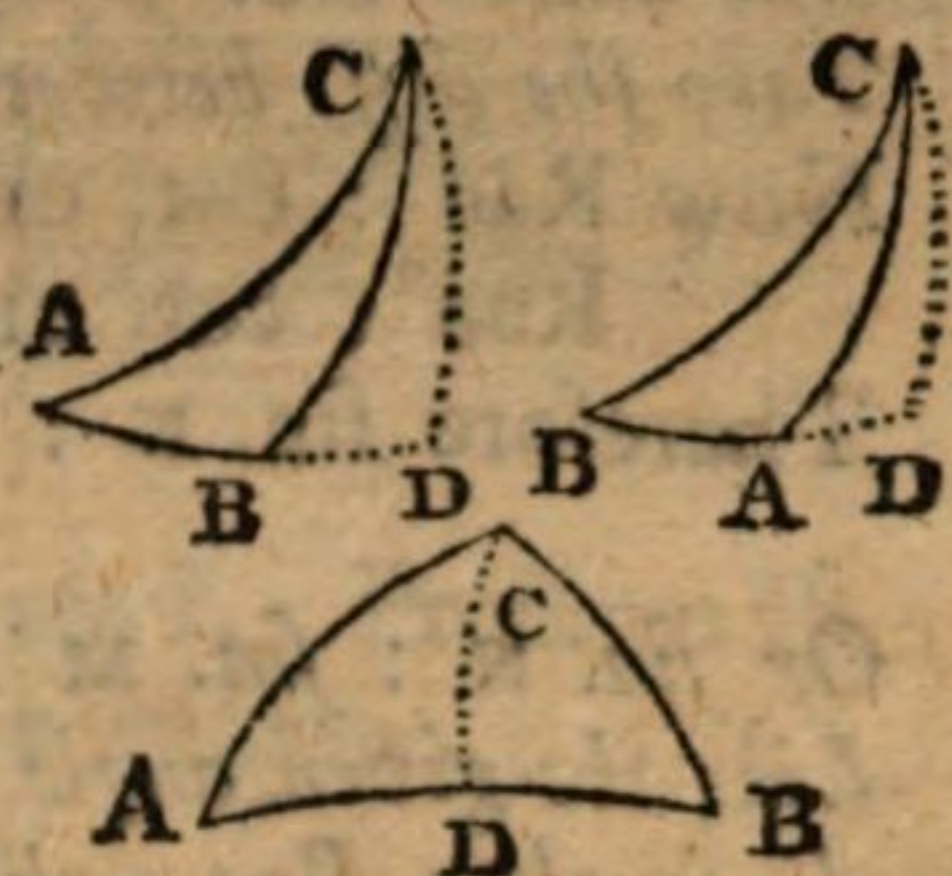
505.

PROBLEM II.

In the oblique angled spheric triangle ABC.

Given two angles $\angle CAB, \angle CBA$ } Required

And a side opposite one of them AC } the rest.



1st. To find the side opposite the other given angle, viz. CB.

Then, As sin. $\angle CBA$: sin. AC :: sin. $\angle CAB$: CB. (493)

Or sin. one ang. : sin. opp. side :: sin. oth. ang. : sin. opp. side.

Which may be either acute or obtuse.

2. To find the side included by the given angles, viz. AB.

Now Rad : cos. $\angle CAB$:: tan. AC : tan. (AD, call it) M. (2d. 497)

Or Rad : cos. $\angle$ adj. giv. side :: tan. the giv. side : tan. (of a fourth =) M.

Like the ang. adj. the side given, if that side is acute; but unlike if obtuse.

But Rad : tan. CD :: cot. $\angle CAB$: sin. (AD =) M.

Rad : tan. CD :: cot. $\angle CBD$: sin. (DB, call it) N. (2d. 498)

Therefore cot. $\angle CAB$: cot. $\angle CBD$:: sin. M : sin. N. (238)

Or cot. $\angle$ adj. giv. side : cot. oth. ang. :: sin. M : sin. N.

Which may be either acute or obtuse.

Then side sought AB = $\begin{cases} \text{sum of M and N, if the given angles are alike.} \\ \text{diff. of M and N, if the given angles are unlike.} \end{cases}$

3d. To find the other angle, viz. $\angle ACB$.

Now Rad : tan. $\angle CAD$:: cos. AC : cot. ($\angle ACD$, call it) m. (3d. 497)

Or Rad : tan. $\angle$ adj. side giv. :: cos. of giv. side : cot. (of a fourth =) M.

Like $\angle$ adj. side given, if that side is acute; but unlike if obtuse.

But cos. CD : Rad :: cos. $\angle CAB$: sin. ($\angle ACD$ =) m.

cos. CD : Rad :: cos. $\angle ABC$: sin. ($\angle BCD$, call it) n. (3d. 498)

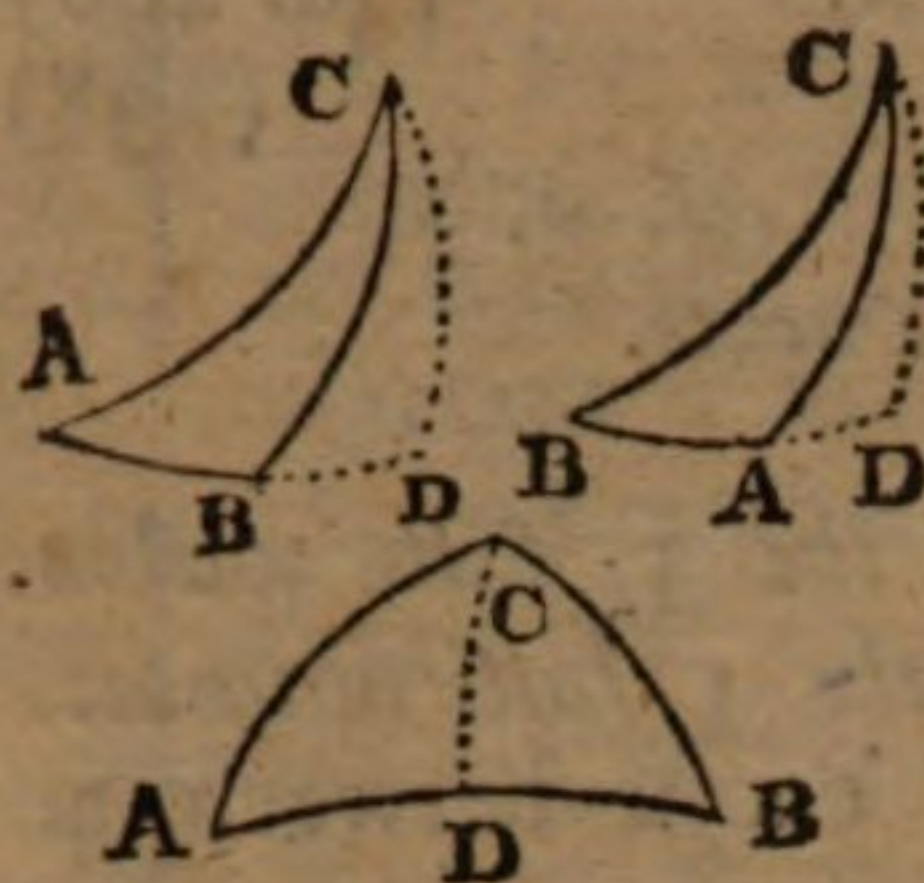
Therefore cos. $\angle CAB$: cos. $\angle ABC$:: sin. m : sin. n. (238)

Or cos. $\angle$ adj. side giv. : cos. other angle :: sin. m : sin. n.

Which may be either acute or obtuse.

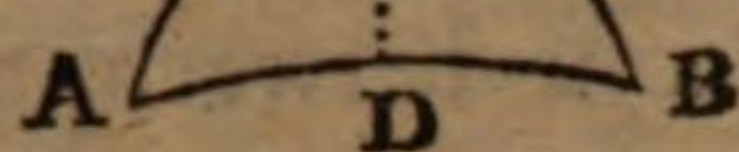
The

Then $\angle$ sought, $ABC = \begin{cases} \text{sum of } m \text{ and } n, \text{ if the given angles are alike.} \\ \text{diff. of } m \text{ and } n, \text{ if the given angles are unlike.} \end{cases}$
 But if $AC = BC$, or to $180^\circ - BC$, or is between BC and $180^\circ - BC$.
 Then BC cannot be unlike its opposite angle.
 Neither can DB , or the $\angle BCD$, be obtuse.



506. PROBLEM III.

In the oblique angled spheric triangles ABC .
 Given two sides AC, AB } Required the rest.
 And their contained angle BAC



1st. To find either of the other angles, as $\angle ABC$.

As $\text{Rad} : \cos. \angle CAB :: \tan. AC : \tan. (AD, \text{ call it } M). \quad (2d. 297)$

Or $\text{Rad} : \cos. \text{giv. } \angle :: \tan. \text{side opp. } \angle \text{ sought} : \tan. (\text{of a fourth } =) M.$

Like the side opp. $\angle$ sought, if the given $\angle$ is acute.

But unlike that side, if the given $\angle$ is obtuse.

Take the diff. between (AB) side adj. $\angle$ sought, and $(AD =) M$; call it N .

Now $\text{Rad} : \cot. CD :: \sin. (AD =) M : \cot. \angle CAB. \quad (1st. 500)$

$\text{Rad} : \cot. CD :: \sin. (DB =) N : \cot. \angle ABC.$

Therefore $\sin. N : \sin. M :: \cot. \angle ABC : \cot. \angle CAB. \quad (238)$

$:: \tan. \angle CAB : \tan. \angle CBA. \quad (332)$

Or $\sin. N : \sin. M :: \tan. \text{giv. } \angle : \tan. \angle \text{ sought}.$

Like the given angle (BAC) if M is less than (AB) the side adjacent the angle sought: But unlike if M is greater.

2d. To find the other side CB .

As $\text{Rad} : \cos. \angle CAB :: \tan. AC : \tan. (AD, \text{ call it } M). \quad (2d. 297)$

Or $\text{Rad} : \cos. \text{giv. } \angle :: \tan. \text{of either giv. side} : \tan. (\text{of a fourth } =) M.$

Like the side used in this proportion if the given angle is acute.

But unlike that side, if the angle is obtuse.

Take the diff. between the other side (AB) and $(AD =) M$; call it N .

Now $\text{Rad} : \cos. CD :: \cos. (AD =) M : \cos. AC. \quad (2d. 500)$

$\text{Rad} : \cos. CD :: \cos. (DB =) N : \cos. CB.$

Therefore $\cos. M : \cos. N :: \cos. AC : \cos. CB. \quad (238)$

Or $\cos. M : \cos. N :: \cos. \text{side used in 1st proportion} : \cos. \text{side required}.$

Like N , if the giv. $\angle$ is acute: But unlike N if that $\angle$ is obtuse.

507.

PROBLEM IV.

In the oblique angled spheric triangle ABC .

Given two angles $\angle CAB, \angle ACB$ } Required the rest.
 And their included side AC

1st. To find either of the other sides, as CB .

As $\text{Rad} : \cos. AC :: \tan. \angle CAB : \cot. (\angle ACD, \text{ call it } m). \quad (3d. 497)$

Or $\text{Rad} : \cos. \text{giv. side} :: \tan. \angle \text{ opp. side sought} : \cot. (\text{of a fourth } =) m.$

Like the angle opp. side sought, if the given side is acute.

But unlike that angle, if the given side be obtuse.

Take the diff. between $\angle (ACB)$ adj. side sought, and $(\angle ACD =) m$, call it n .

Then $\text{Rad} : \cot. CD :: \cos. (\angle ACD =) m : \cot. AC. \quad (3d. 499)$

$\text{Rad} : \cot. CD :: \cos. (\angle BCD =) n : \cot. CB.$

Therefore

Therefore $\cos. n : \cos. m :: \cot. CB : \cot. AC.$ (238)
 $:: \tan. AC : \tan. CB.$ (332)

Or $\cos. n : \cos. m :: \tan. \text{given side} : \tan. \text{side required.}$

Like n , if the angle opposite the side sought be acute.

But unlike n if the angle is obtuse.

2d. To find the other angle ABC .

As $\text{Rad} : \cos. AC :: \tan. \angle CAB : \cot. (\angle ACD,$
 call it) $m.$ (3d. 497)

Or $\text{Rad} : \cos. \text{giv. side} :: \tan. \text{either giv. } \angle : \cot.$
 (of a fourth $=$) $m.$

Like $\angle$ used in this proportion, if the giv. side (AC)
 is acute.

But unlike that $\angle$, if the given side is obtuse.

Take the diff. between the other $\angle$ (ACB) and
 $\angle$ ($ACD =$) m , call it n .

Now $\text{Rad} : \cos. CD :: \sin. (\angle ACD =) m : \cos. \angle CAB.$ (1st. 499)

$\text{Rad} : \cos. CD :: \sin. (\angle BCD =) n : \cos. \angle ABC.$

Therefore $\sin. m : \sin. n :: \cos. \angle CAB : \cos. \angle ABC.$ (238)

Or $\sin. m : \sin. n :: \cos. \angle \text{used in 1st prop.} : \cos. \angle \text{sought.}$

Like the $\angle$ used in both proportions, if m is less than the other $\angle$.

But unlike, if m is greater than the other angle.

508. PROBLEM V.

In the oblique angled spheric triangle ABC . Plate I. Problem V.

Given the three sides AB, BC, AC ; Required the angles.

To find the angle ABC .

Let $HBKLM$ represent the quarter of a sphere, whose centre is O .
 Where the semicircular sections HBK, HLK , are at right angles to one
 another; and OB is perpendicular to HK .

Then, continuing the side BC to L , the arc HML measures $\angle ABC$. (389)

And $HQ = \frac{1}{2}$ chord HL , will be the sine of $\frac{1}{2}$ (arc $HML = \frac{1}{2}$) $\angle ABC$.

Draw the radius OQM ; and draw LP, QN at right angles to HK .

Then $LP =$ sine, $HP =$ versed sine, of $\angle ABC$: And $HN = NP$. (248)

But as HQO is a right angled triangle; OQ being perp. to HL . (208)

Therefore $OH : HQ :: HQ : HN.$ (253)

And $OH \times HN = \overline{HQ}^2$ (245) = square of the sine of $\frac{1}{2} \angle ABC$.

Make $BD = BE = BC$; and $AF = AG = AC$.

Then the semicircular plane DCE , which is parallel to HLK (403), will
 be cut by the semicircular plane FCG , drawn at right angles to the plane
 HBK , in the line CI (283) at right angles to DE . (284)

And the arc DC and its versed line DI , are similar to the arc HL and
 its versed line HP . (409, 310)

Then $\text{Rad } OH : \text{Rad } DS :: PH : ID = \left(\frac{PH}{OH} \times DS = \right) \frac{2HN}{OH} \times DS.$

Draw OR parallel to FG ; then arc $AR = (90^\circ =)$ arc BK , and $RK = AB$.

Therefore $\angle DIF = (\angle KOR = \text{arc } RK =)$ arc AB .

Now $DS = (SE = \text{fine arc } BE =)$ fine arc BC .

And $AD = (BD - BA = BC - BA =)$ diff. sides about $\angle$ sought.

Also $\angle DFI = \frac{1}{2}$ arc $(DG = AG + AD =) AC + AD$, whose sine is $\frac{1}{2} ID$.

Schol. to art. 340.

And arc $FD = (AF - AD =) AC - AD$, whose sine is $\frac{1}{2} DF$.
 Now

Now $\sin. \angle DIF : \sin. \angle DFI :: (FD : ID ::) \frac{1}{2} FD : \frac{1}{2} ID$. (Schol. 340)

Or $\sin. \angle DIF : \sin. \angle DFI :: \frac{1}{2} FD : \frac{HN}{OH} \times DS$.

Therefore $\sin. \angle DIF \times DS \times \frac{HN}{OH} = \sin. \angle DFI \times \frac{1}{2} FD$. (245)

Therefore $\sin. \angle DIF \times DS \times \frac{HN}{OH} \times OH = \sin. \angle DFI \times \frac{1}{2} FD \times OH$. (239)

Or $\sin. \angle DIF \times DS \times HN = \sin. \angle DFI \times \frac{1}{2} FD \times OH$. (232)

Theref. $\sin. \angle DIF \times DS : \sin. \angle DFI \times \frac{1}{2} FD :: OH : HN$. (246)

$:: OH \times OH : (HN \times OH = \overline{HQ}^2)$. (234)

Therefore $\sin. \angle DIF \times DS : \sin. \angle DFI \times \frac{1}{2} FD :: \overline{OH}^2 : \overline{HQ}^2$.

Or $\sin. AB \times \sin. BC : \sin. \frac{1}{2} AC + AD \times \sin. \frac{1}{2} AC - AD :: \text{Rad}^2 : \sin. \frac{1}{2} \angle ABC^2$.

Theref. square $\sin. \frac{1}{2} \angle ABC = \frac{\sin. \frac{1}{2} AC + AD \times \sin. \frac{1}{2} AC - AD}{\sin. AB \times \sin. BC} \times \text{squ. Rad.}$ (247)

Now supposing $\text{Rad} = 1$. and L , to stand for logarithm.

Then $2L, \sin. \frac{1}{2} \angle ABC = L. \sin. \frac{1}{2} AC + AD + L. \sin. \frac{1}{2} AC - AD - L. \sin. AB - L. \sin. BC$. (90. 85. 86).

And putting l for the arith. comp. of a logarithm.

Then $L, \sin. \frac{1}{2} \angle ABC = \frac{l, \sin. AB + l, \sin. BC + L. \sin. \frac{1}{2} AC + AD + L. \sin. \frac{1}{2} AC - AD}{2}$.

That is, having determined which angle to find.

To the arith. comp. of log. sin. of one containing side,

Add the arith. comp. of log. sin. of the other containing side,

And the log. sin. of the $\frac{1}{2}$ sum of 3d side and diff. of the containing sides,

Also the log. sin. of the $\frac{1}{2}$ diff. of 3d side and diff. of the containing sides.

Then the degrees answering to half the sum of these four logs, found among the sines, being doubled, will give the angle sought.

509.

PROBLEM VI.

In the oblique angled spheric triangle ABC.

Given the three angles A, B, c; Requ. the sides.

To find the side AB.

About the given angles as poles, describe arcs of great circles meeting one another, and forming the triangle FDE.

Then are the sides of FDE, the supplements of the angles A, B, c. (475)

Continue FD, FE, the supplements of the angles B, A, adjacent to the side AB required, till they meet in G.

Then in the triangle DGE, the sides GD, GE, are the measures of the angles B and A, adjacent to the side sought.

The side DE is the supplement of $\angle c$ opp. the side AB.

Now $\angle G (= \angle F$, by 411) is the supplement of AB.

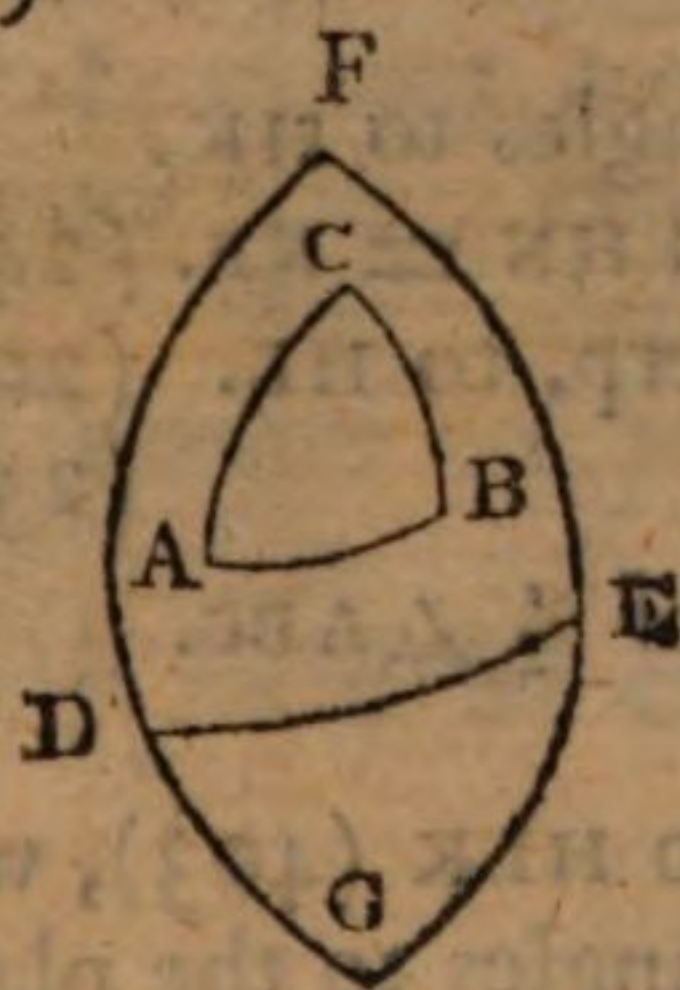
Therefore the $\angle G$ being found in the triangle DGB by PROB. V, (508) will give the supplement of the side AB required.

That is, Let the given angles be taken as the sides of another triangle, observing to use the supplement of that angle opp. to the side required.

In this new triangle find (by PROB. V), the angle opposite to that side where the supplement is used.

Then will the supplement of the angle thus found be the side required.

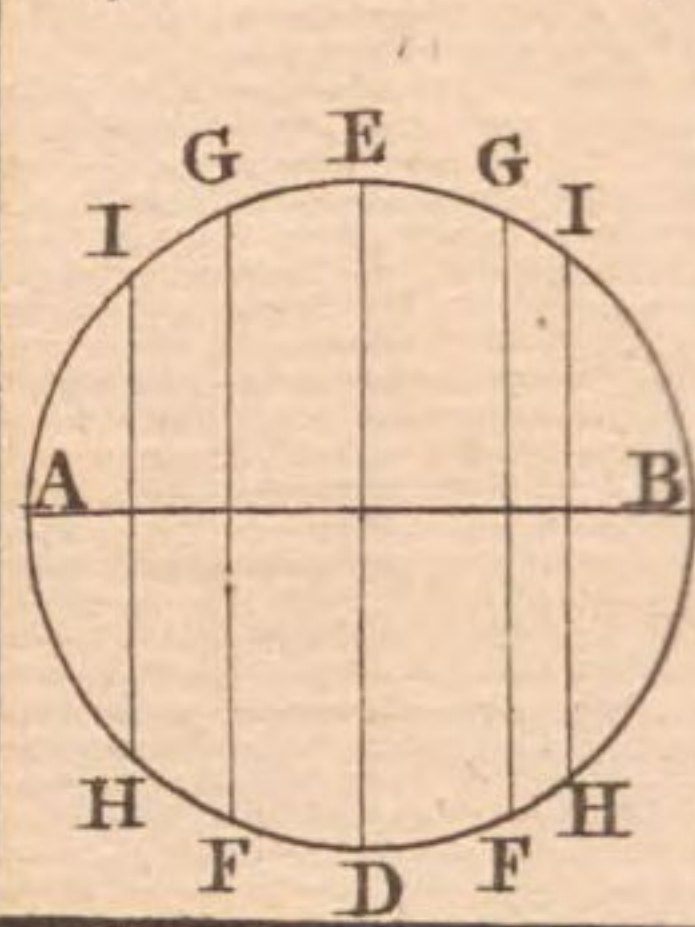
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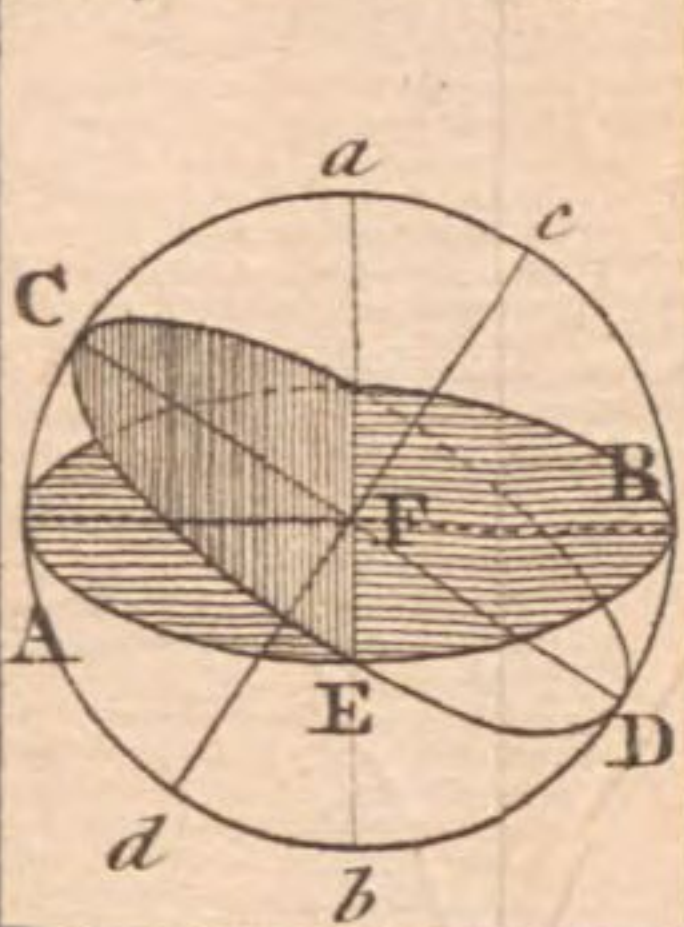
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Pl. I.

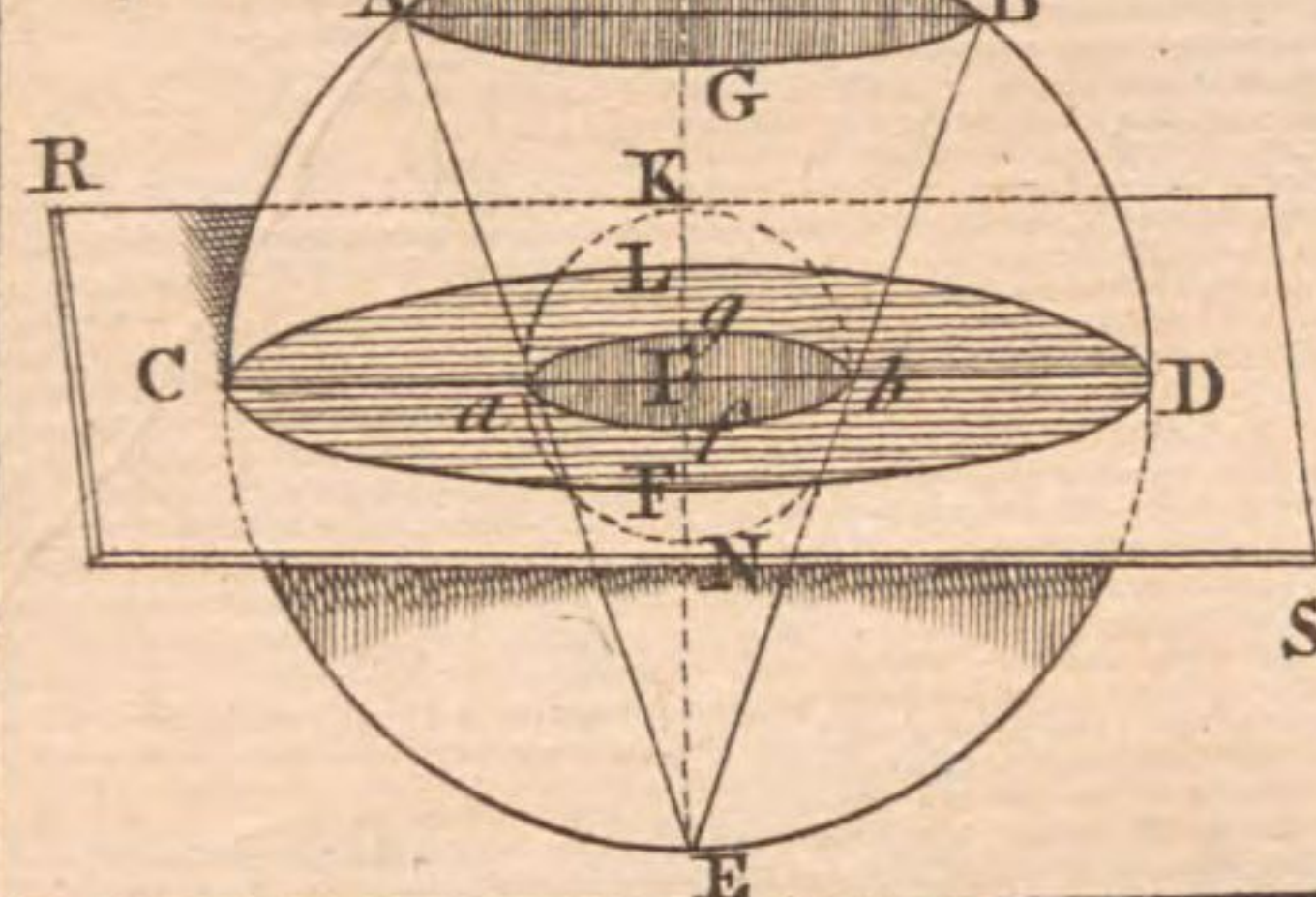
Definitions. Pa. 117



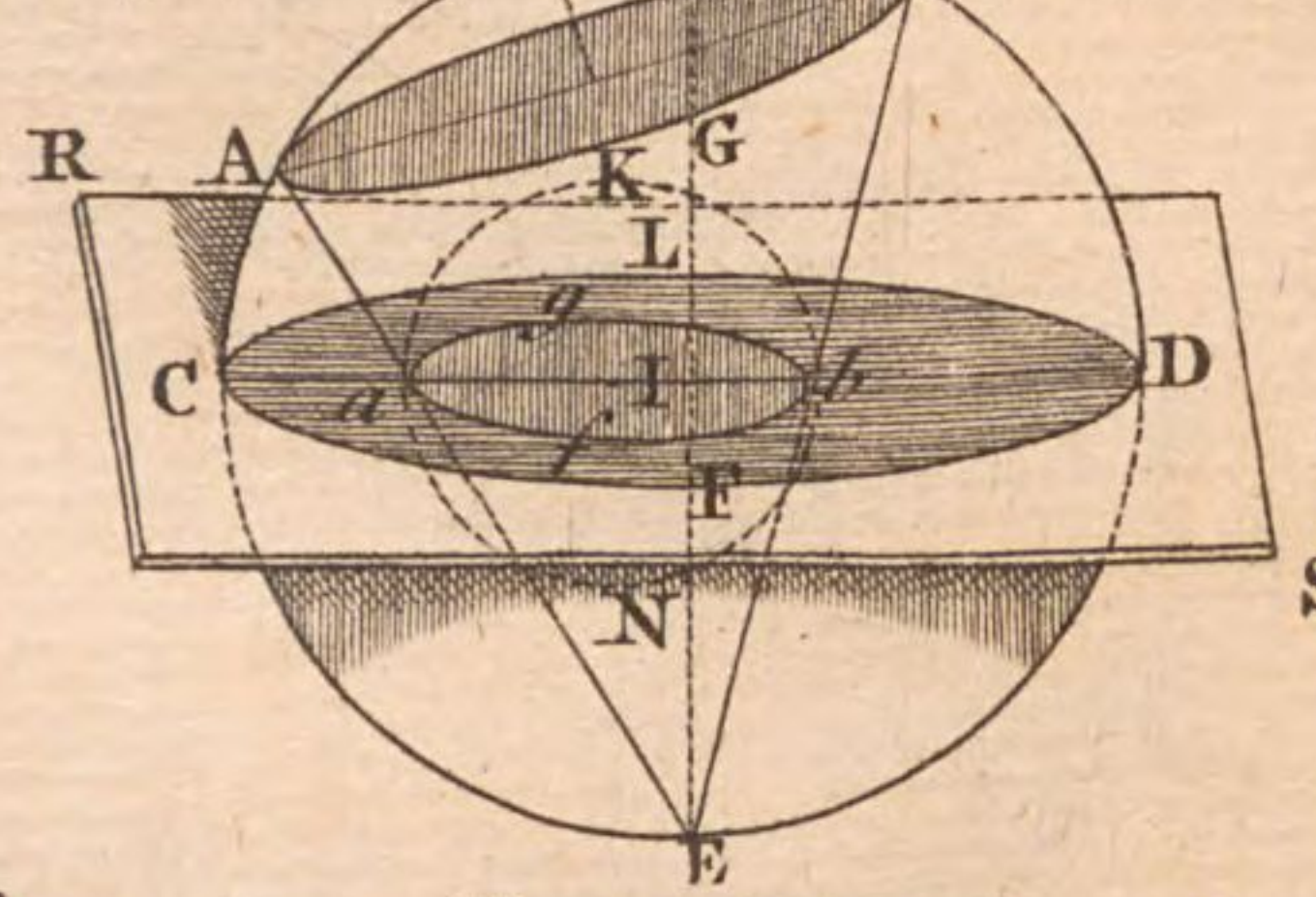
Prop. II. Pa. 119



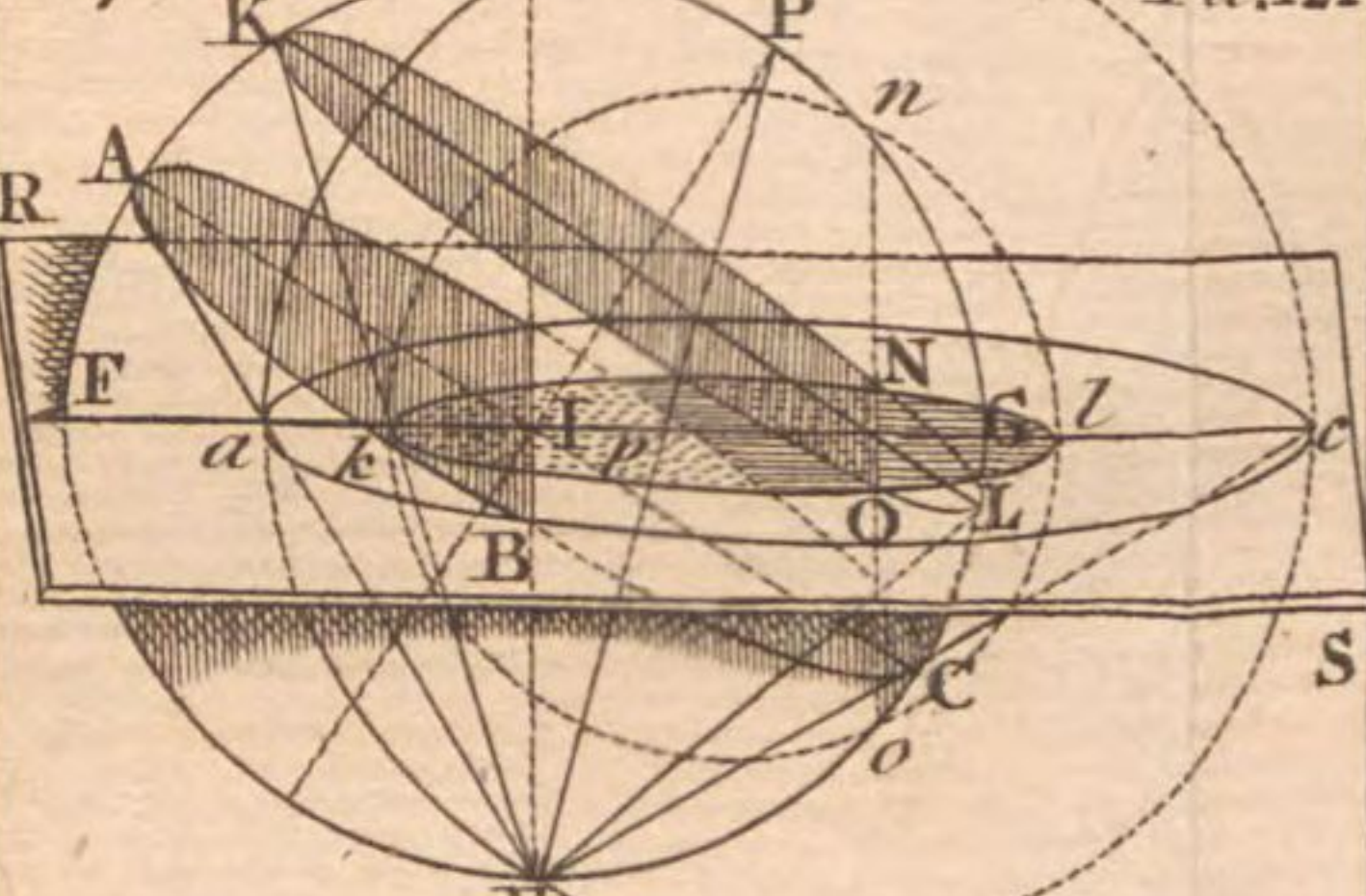
Prop. III. Pa. 120



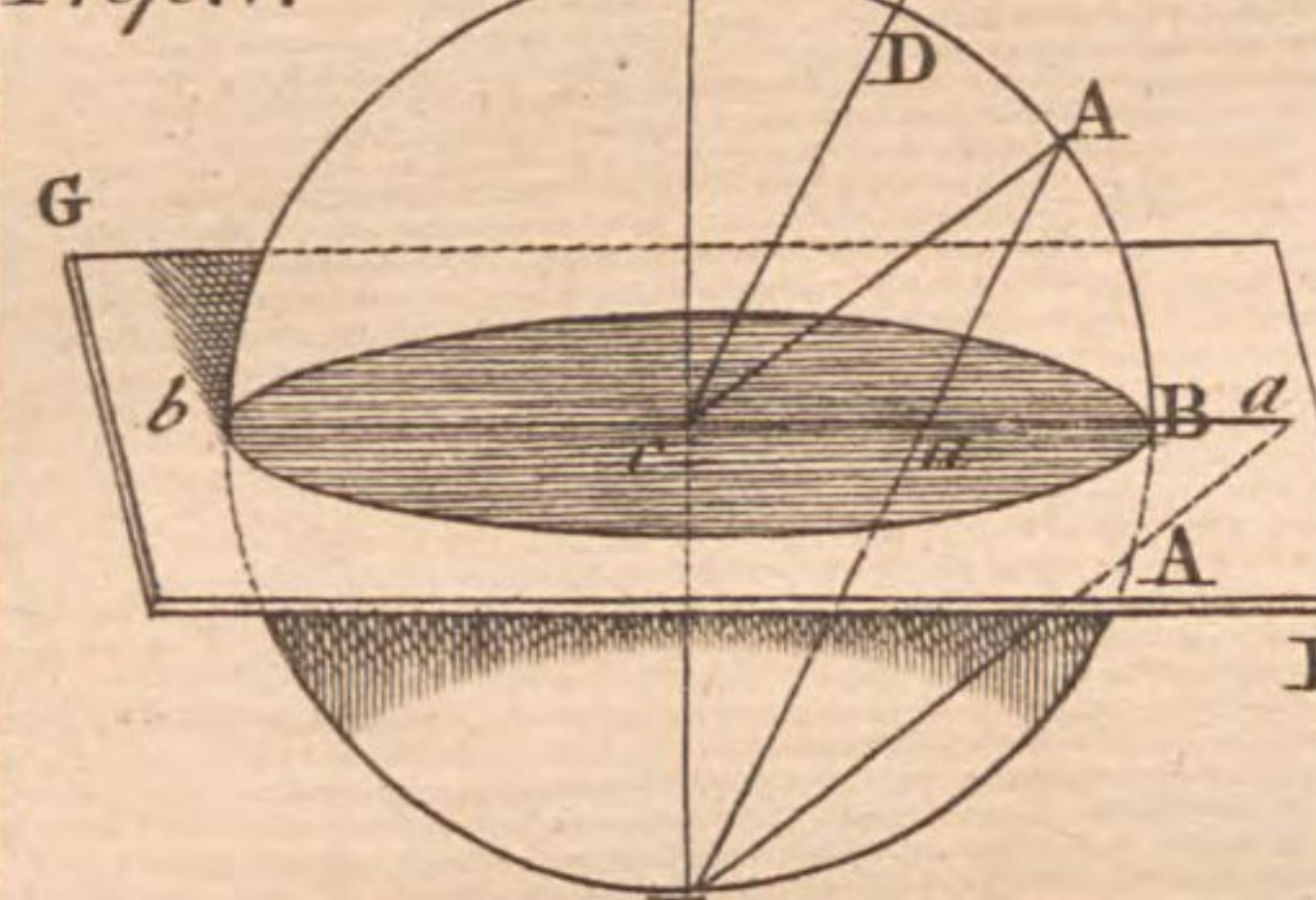
Prop. III. Pa. 120



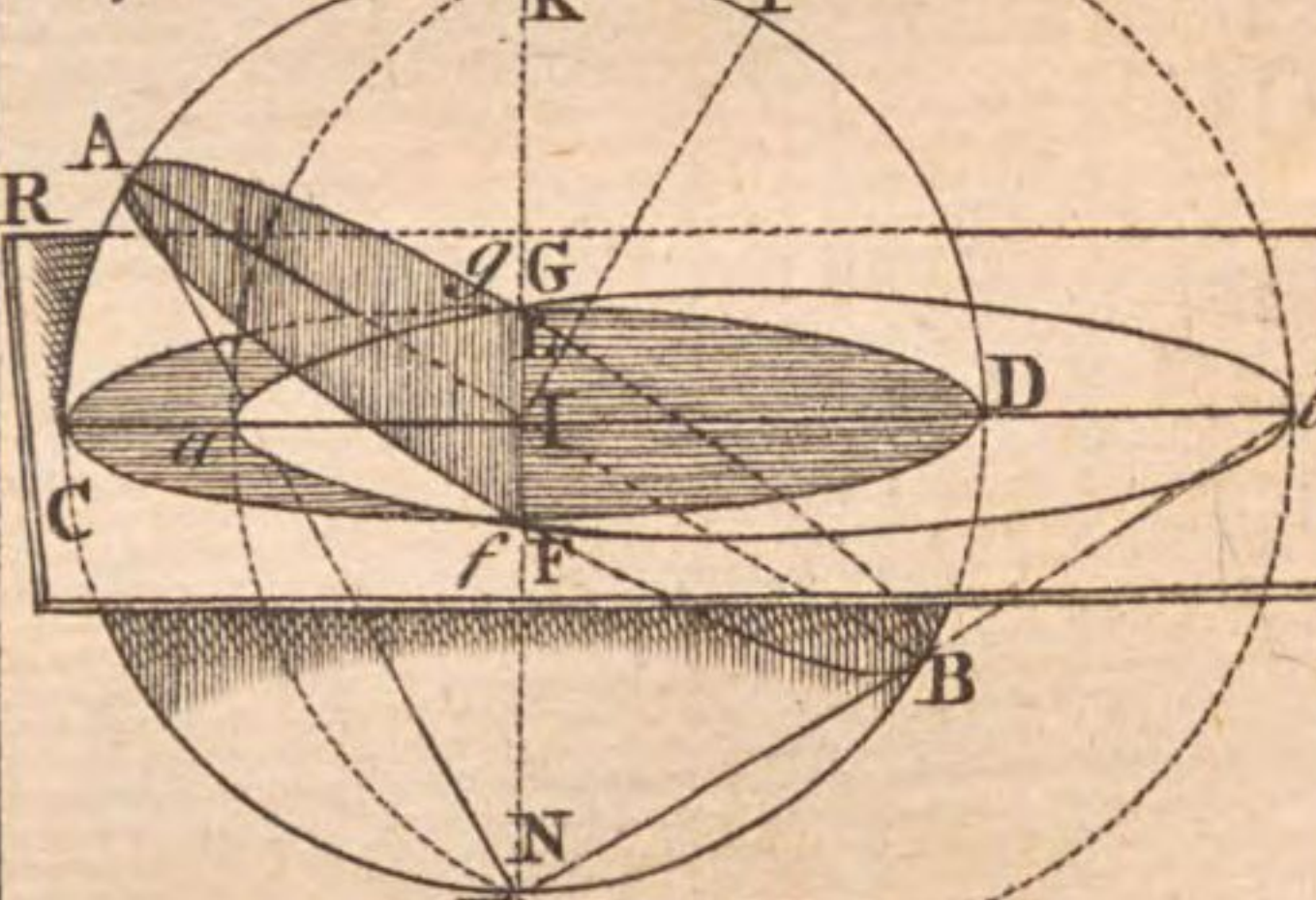
Prop. IV. Pa. 121



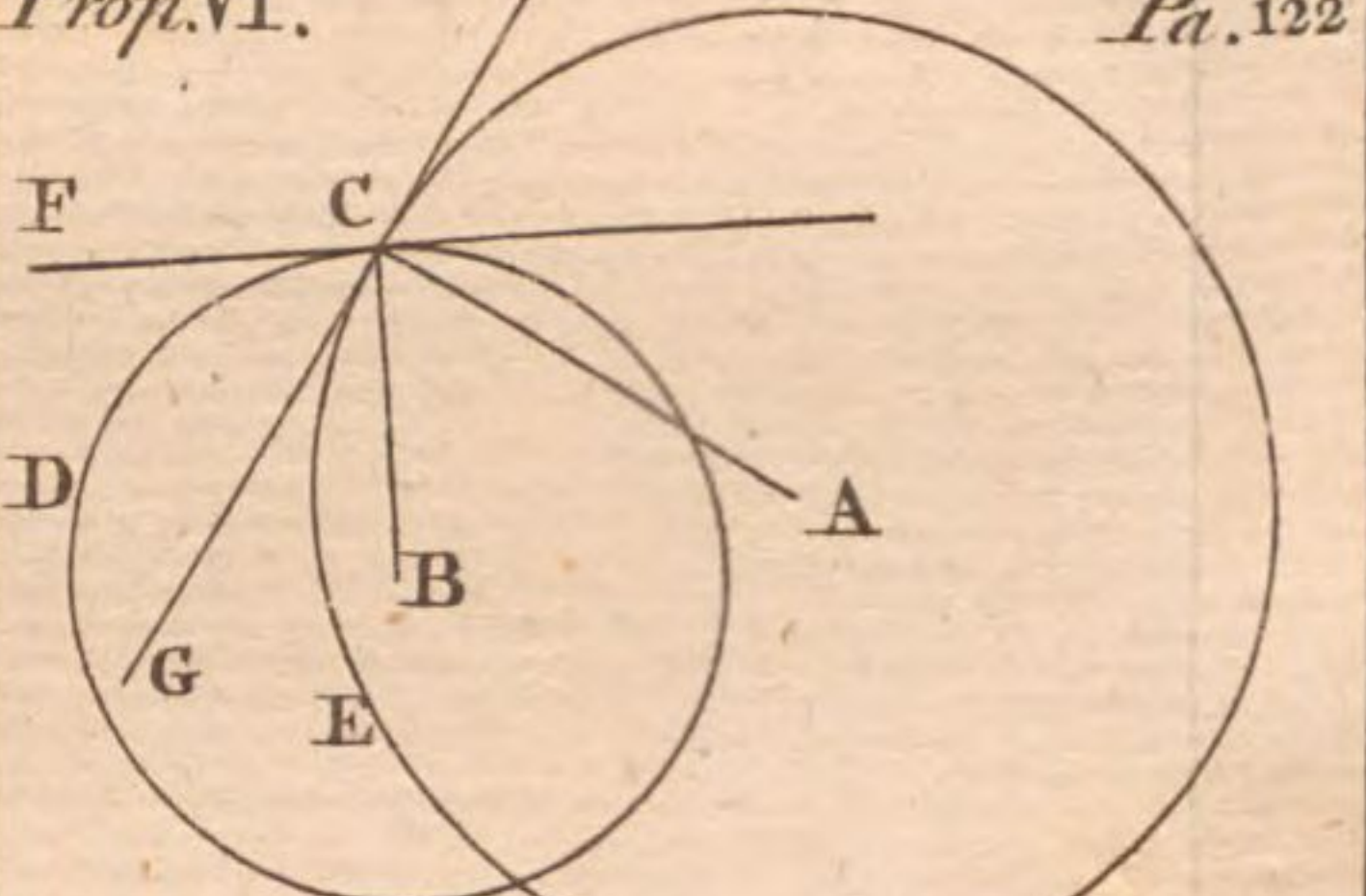
Prop. V. Pa. 122



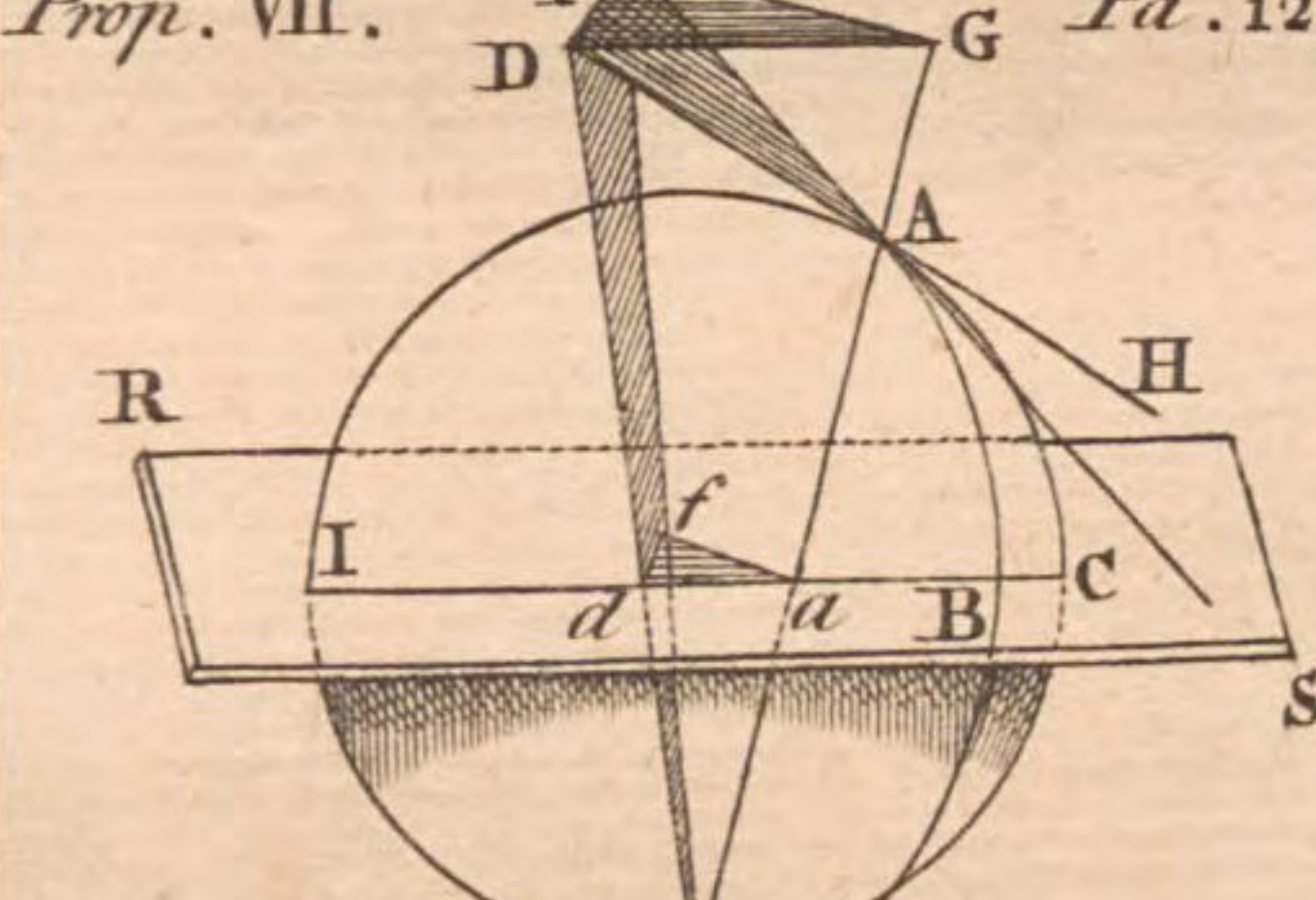
Prop. III. Pa. 120



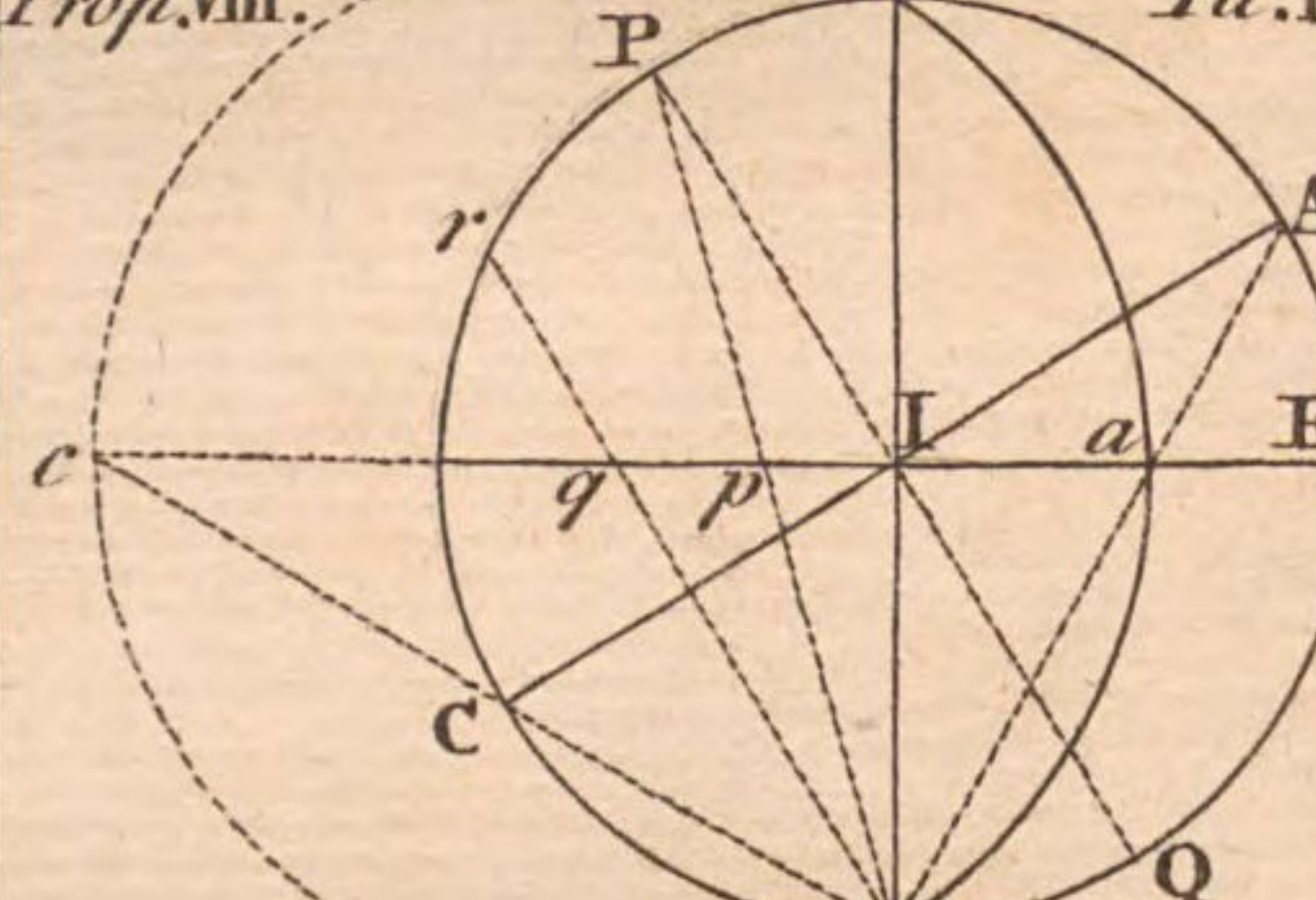
Prop. VI. Pa. 122



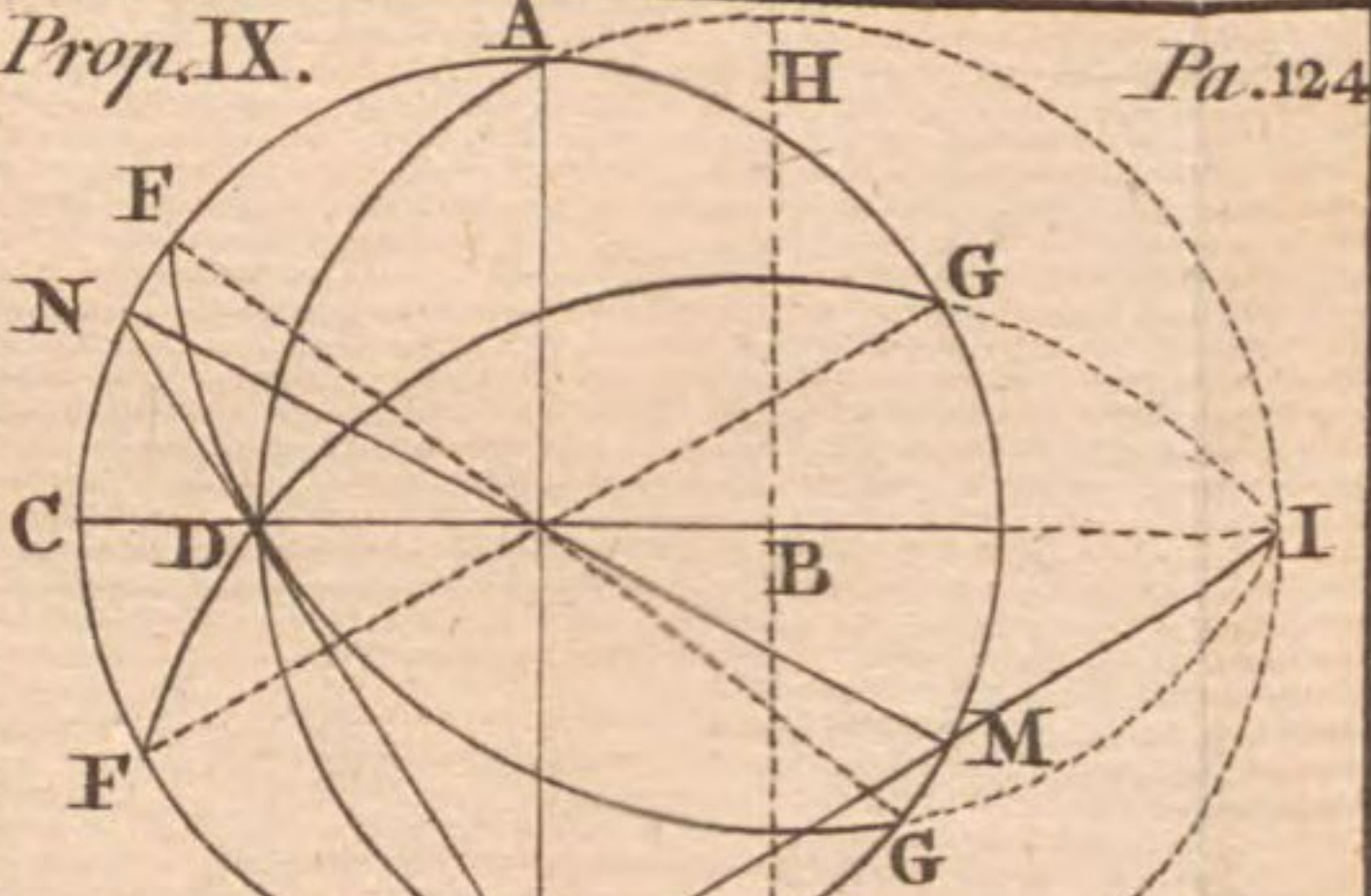
Prop. VII. Pa. 123



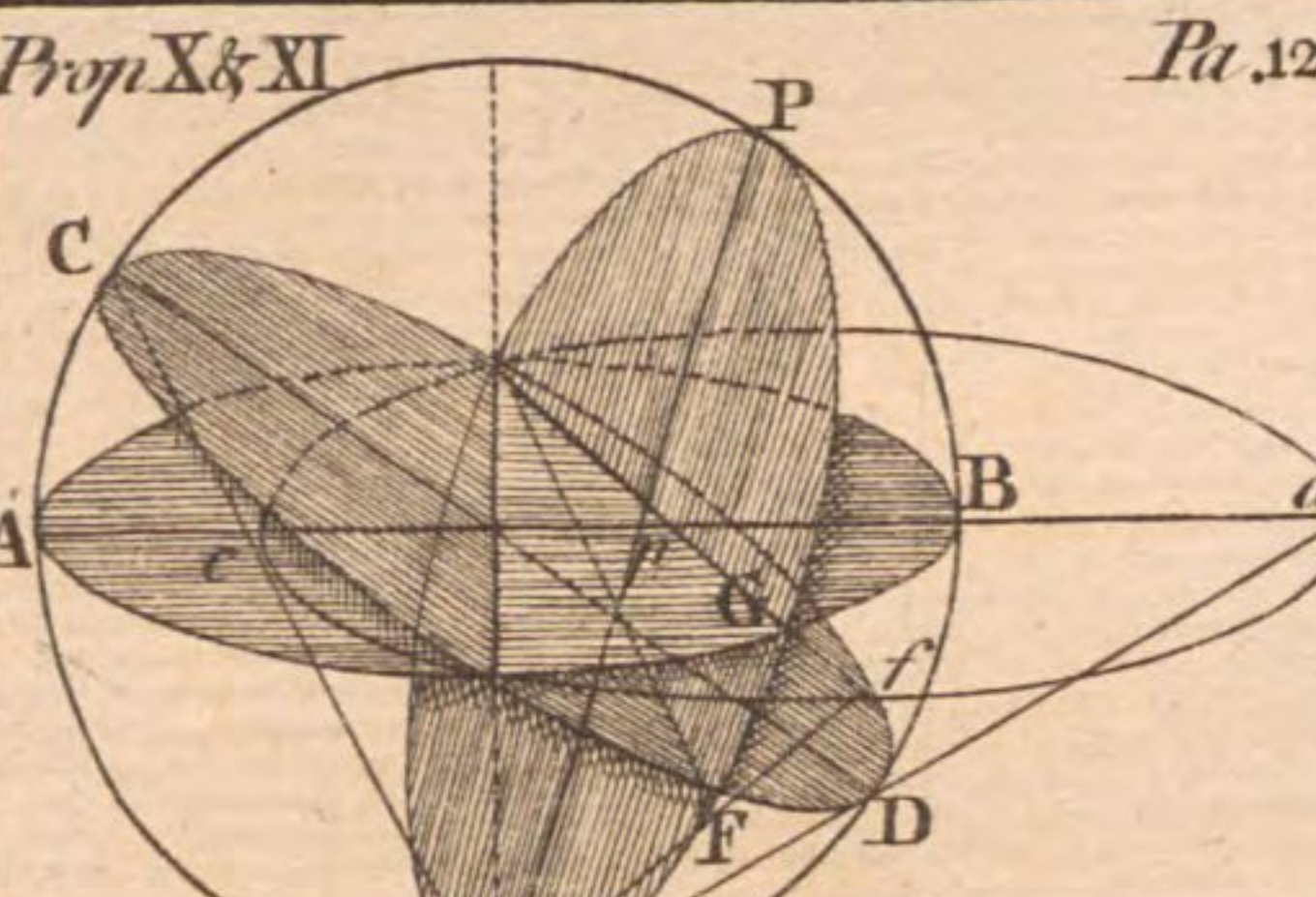
Prop. VIII. Pa. 123



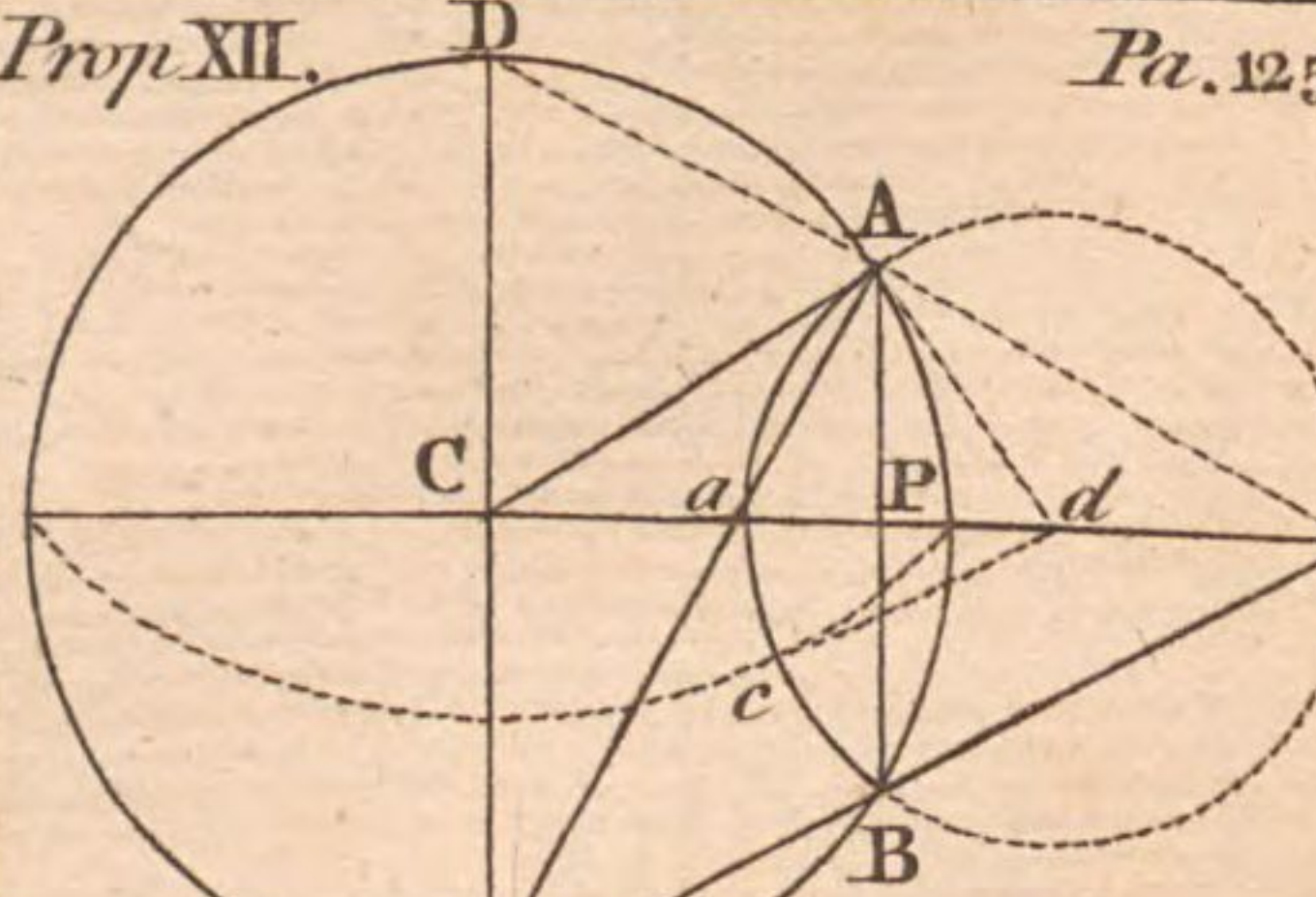
Prop. IX. Pa. 124



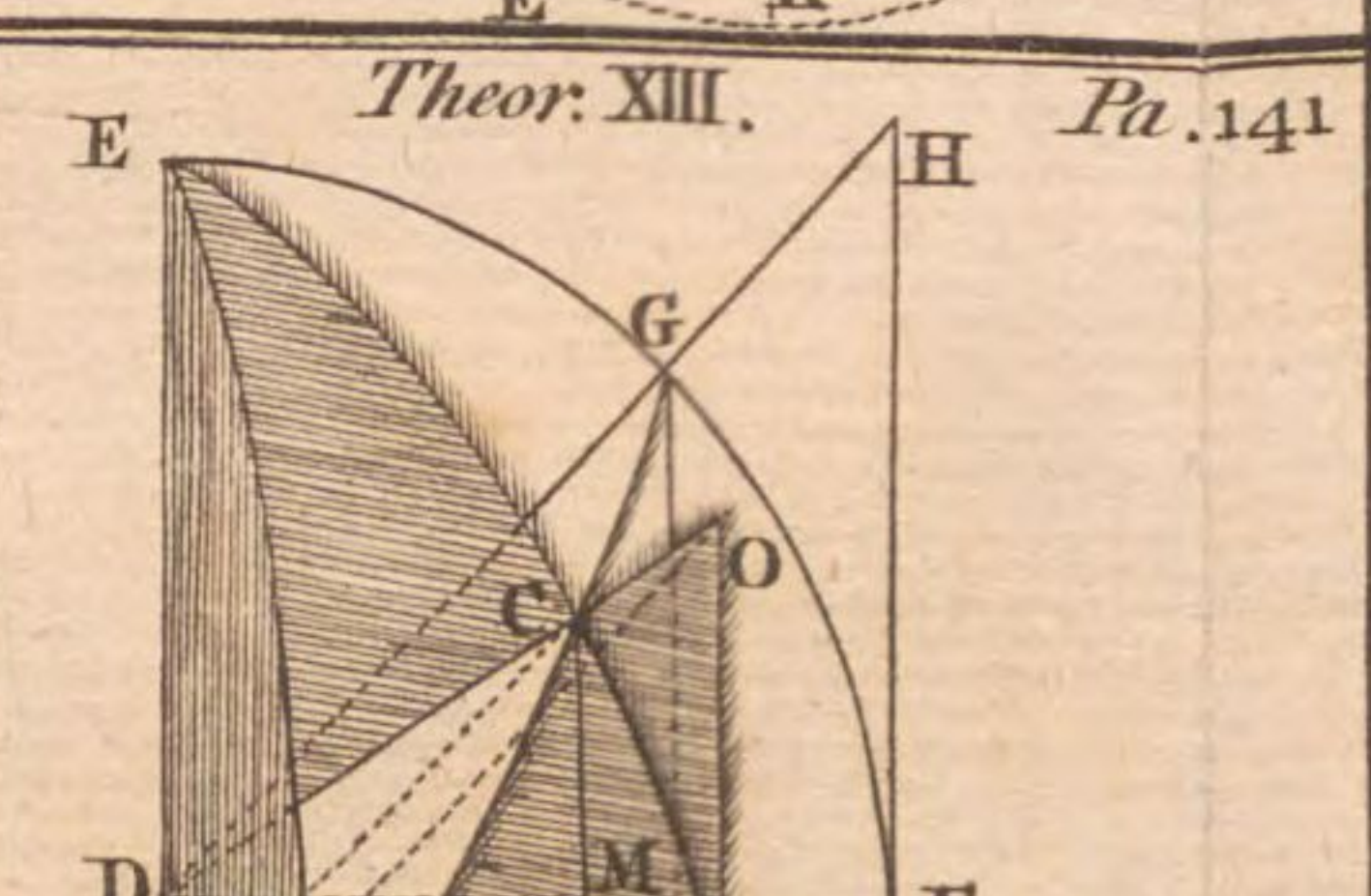
Prop. X & XI. Pa. 124



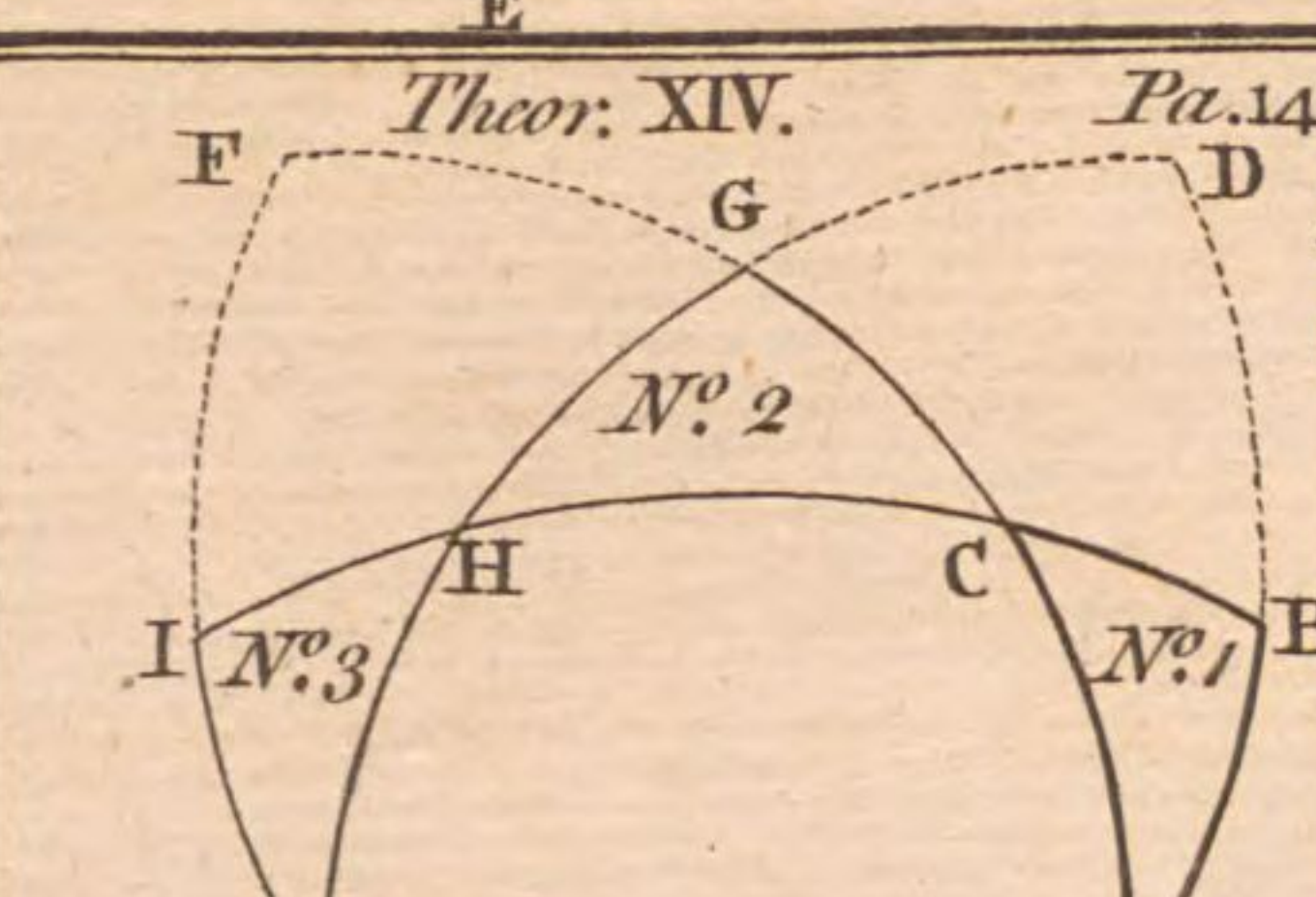
Prop. XII. Pa. 125



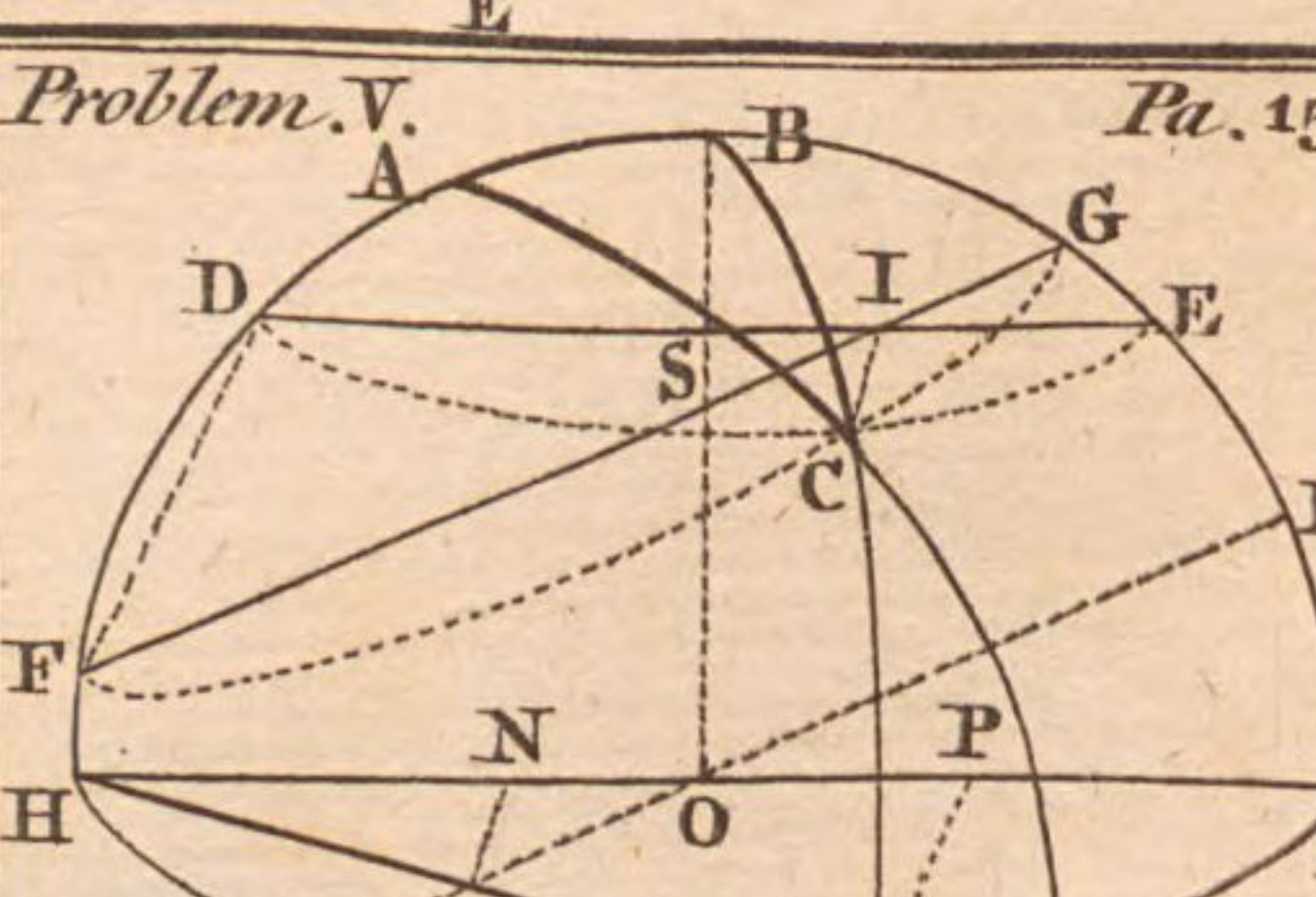
Theor. XIII. Pa. 141



Theor. XIV. Pa. 142



Problem. V. Pa. 151



A TABLE containing all the cases of Right angled, or Quadrantal, spheric triangles, with the Solutions, and Determinations.

PROB.	Given.	Required.	SOLUTION.	Determination.
510.		$\angle$ op. gn. leg	$\sin. Hyp. : Rad :: \sin. gn. leg : \sin. op. \angle$	Like given leg.
511.	I. Hyp. and a leg	$\angle$ ad. gn. leg	$Rad : \cot. Hyp. :: \tan. gn. leg : \cos. adj. leg$	{ ac. or ob. as hyp. lik. or unl. gn. leg.
512.		oth. leg.	$\cos. gn. leg : Rad :: \cos. Hyp. : \cos. req. leg$	
513.		leg op. gn. $\angle$	$Rad : \sin. Hyp. :: \sin. gn. \angle : \sin. op. leg$	Like given angle.
514.	II. Hyp. and an angle.	leg ad. gn. $\angle$	$Rad : \tan. Hyp. :: \cos. gn. \angle : \tan. adj. leg$	{ ac. or ob. as hyp. lik. or unl. gn. $\angle$
515.		oth. angle	$Rad : \cos. Hyp. :: \tan. gn. \angle : \cot. req. \angle$	
516.	III. A leg and its op. $\angle$	Hypoth.	$\sin. gn. \angle : \sin. gn. leg :: Rad : \sin. Hyp.$	either ac. or ob.
517.		oth. leg	$Rad : \cot. gn. \angle :: \tan. gn. leg : \sin. req. leg$	either ac. or ob.
518.		oth. angle	$\cos. g. leg : \cos. gn. \angle :: Rad : \sin. req. \angle$	either ac. or ob.
519.	IV. A leg and its adj. $\angle$	oth. ang.	$Rad : \cos. gn. leg :: \sin. gn. \angle : \cos. req. \angle$	Like given angle.
520.		oth. leg.	$Rad : \sin. gn. leg :: \tan. gn. \angle : \tan. req. leg$	Like given leg.
521.		Hypoth.	$Rad : \cos. gn. \angle :: \cot. gn. leg : \cot. Hyp.$	{ ac. or ob. as gn. leg. lik. or unl. gn. $\angle$.
522.	V. Both legs.	either ang.	$Rad : \sin. eith. leg :: \cot. oth. leg : \cot. op. \angle$	Like opp. leg.
523.		Hypoth.	$Rad : \cos. eith. leg :: \cos. oth. leg : \cos. Hyp.$	{ ac. or ob. as legs like or unlike.
524.	VI. Both angles	eith. leg.	$\sin. eith. \angle : Rad :: \cos. oth. \angle : \cos. op. leg$	Like opp. angle.
525.		Hypoth.	$Rad : \cot. eith. \angle :: \cot. oth. \angle : \cos. Hyp.$	{ ac. or ob. as $\angle$ s lik. or unl.

526. In a quadrantal triangle, if the quadrantal side be called radius; the supplement of the angle opposite to that side be called hyp.; the other sides be called angles, and their opposite angles be called legs: Then the solution of all the cases will be as in this table; observing, that where the kind of a side or angle is determined by the hyp.; or the hyp. is to be determined, to use unlike instead of like, and like instead of unlike.

In this table, beside the contractions for sine, tang. cosine, cotang, *op.* stands for opposite; *adj.* for adjacent; *oth.* for other; *eith.* for either; *ac.* for acute; *ob.* for obtuse; *gn.* for given; *lik. unl.* for like, unlike; *req.* for required; *ang.* or $\angle$, for angle.

A TABLE containing all the cases of Oblique angled Spheric triangles, with the Solutions and Determinations.

PROB.	Given	Required	SOLUTION.	Determination.
527.		$\angle$ op. oth. fid.	$\text{fin. one side} : \text{fin. op. } \angle :: \text{fin. oth. side} : \text{fin. op. } \angle$	either ac. or ob.
528.	I. Two sides and an ang. op. to one	$\angle$ bet. gn. fid.	Rad : tan. gn. $\angle :: \text{cof. adj. fid.} : \text{cot.}$ $\text{cot. fid. adj. gn. } \angle : \text{cot. oth. fid.} :: \text{cof. } m : \text{cof. } n$ Then req. angle is either equal to sum, or diff. of m and n .	$\left\{ \begin{array}{l} \text{ac. or ob. as gn. angle and it} \\ \text{adj. side are like or unlike.} \end{array} \right.$ $\left\{ \begin{array}{l} \text{like or unlike fid. op. gn. angl.} \\ \text{as that angl. is ac. or ob.} \\ \text{as gn. sides are like or unlike.} \end{array} \right.$
529.		other side	Rad : cof. gn. $\angle :: \text{tan. adj. fid.} : \text{tan. } M$ $\text{cof. S. adj. gn. } \angle : \text{cof. oth. S.} :: \text{cof. } M : \text{cof. } N$ Then required side = sum or diff. of M and N ,	$\left\{ \begin{array}{l} \text{ac. or ob. as given angl. and it} \\ \text{adj. side are like or unlike.} \end{array} \right.$ $\left\{ \begin{array}{l} \text{like or unlike side op. gn. angl.} \\ \text{as that angl. is ac. or ob.} \\ \text{as the given sides are lik. or unl.} \end{array} \right.$
530.		$S.$ op. oth. $\angle$	$\text{fin. one angle} : \text{fin. op. } S. :: \text{fin. oth. angle} : \text{fin. op. } S.$	either ac. or ob.
531.	II. Two angles and a side op. to one	$S.$ bet. gn. $\angle$ s	Rad : $\text{cof. } \angle \text{ adj. gn. } S. :: \text{tan. gn. } S. : \text{tan. } M$ $\text{cot. } \angle \text{ adj. gn. } S. : \text{cot. oth. ang.} :: \text{fin. } M : \text{fin. } N$ Then required side = sum or diff. of M and N ,	$\left\{ \begin{array}{l} \text{lik. or unl. angl. adj. gn. side, as} \\ \text{that side is ac. or ob.} \end{array} \right.$ $\left\{ \begin{array}{l} \text{either ac. or ob.} \\ \text{as the given angles are like or} \\ \text{unlike.} \end{array} \right.$
532.		other angle	Rad : $\text{tan. } \angle \text{ adj. gn. } S. :: \text{cof. gn. fid.} : \text{cot. } m$ $\text{cof. } \angle \text{ adj. gn. } S. : \text{cof. oth. ang.} :: \text{fine } m : \text{fine } n$ Then required angle = sum or diff. of m and n ,	$\left\{ \begin{array}{l} \text{lik. or unl. angl. adj. gn. side,} \\ \text{as that side is ac. or ob.} \end{array} \right.$ $\left\{ \begin{array}{l} \text{either ac. or ob.} \\ \text{as the given angles are like or} \\ \text{unlike.} \end{array} \right.$
533.		either of oth. angles	Rad : $\text{cof. gn. ang.} :: \text{tan. S. op. req. } \angle : \text{tan. } M$ Take the diff. between side adj. req. angle and M , call it N . fine N : fine $M :: \text{tan. gn. angle} : \text{tan. req. } \angle$	$\left\{ \begin{array}{l} \text{like or unlike side op. req. angl.} \\ \text{as given angle is ac. or ob.} \end{array} \right.$ $\left\{ \begin{array}{l} \text{like or unlike gn. angle, as } M \text{ is} \\ \text{less or greater than S. adj. req. } \angle. \end{array} \right.$
533.	III. Two sides			

534.	and their included $\angle$	other side	Rad : cof. gn. ang. :: tan. eith. gn. S. : tan. m Take the diff. between the other side and m, call it n. cof. m : cof. n :: cof. S. ift used : cof. req. S.	{ lik. or unl. side used, as given angle is acute or obtuse. { like or unlike n, as given angle is acute or obtuse.
535.	Two angles and their includ. side	either of oth. sides	Rad : cof. gn. side :: tan. $\angle$ op. req. S. : cot. m Take the diff. between $\angle$ adj. required side and m, call it n. cof. n : cof. m :: tan. gn. side : tan. req. S.	{ like or unlike angl. op. req. side, as given side is acute or obtuse. { like or unlike n, as the angle op. req. side is ac. or ob.
536.		oth. angle	Rad : cof. gn. side :: tan. eith. gn. $\angle$: cot. m Take the diff. between the other angle and m, call it n. fine m : fine n :: cof. $\angle$ ift used : cof. req. $\angle$	{ like or unlike angle used, as given side is acute or obtuse. { like or unlike angle here used, as m is less or greater than oth. angl.
537.	Three sides	either angle	Call the sides including the angle sought E and F; the opposite side call G. Put D equal to diff. between E and F; Find the half sum and half diff. of G and D. Then, To the Ar. Co. of Log. fin. of E, add the Ar. Co. of Log. fin. of F, And the Log. fine of $\frac{1}{2}$ sum of G and D; Also the Log. fine of $\frac{1}{2}$ diff. of G and D. Take half the sum of these four Logs. which seek among the log. fines; And the degrees and minutes being doubled, will give the angle sought.	
538.	Three angles	either side	Let the given angles be taken as the sides of another triangle, observing to use the supplement of that angle opposite the side required. In this new triangle, find the angle opposite to that side where the supplement is used, by the precepts in Prob. V. Then will the supplement of the angle thus found be the side required.	

SECTION VIII.

The construction and numeral solution of the cases of right angled spheric triangles.

539. EXAM. I. In the right angled spheric triangle ABC.
 Given the hypoth. $AC = 64^\circ 40'$
 And one leg $BC = 42^\circ 12'$ } Required the rest.

CONSTRUCTIONS.

1st. *To put the given leg on the primitive circle.*

Describe the primitive circle, and draw the right circle AB.

Apply the given leg ($42^\circ 12'$) to the primitive circle from B to c.

About c as a pole, at a dist. equal to the hyp. ($64^\circ 40'$) (456) describe a small circle aa , cutting the right circle AB in A; and draw the right circle CD.

Thro' c, A, D, describe an oblique circle.

And ABC is the triangle sought.

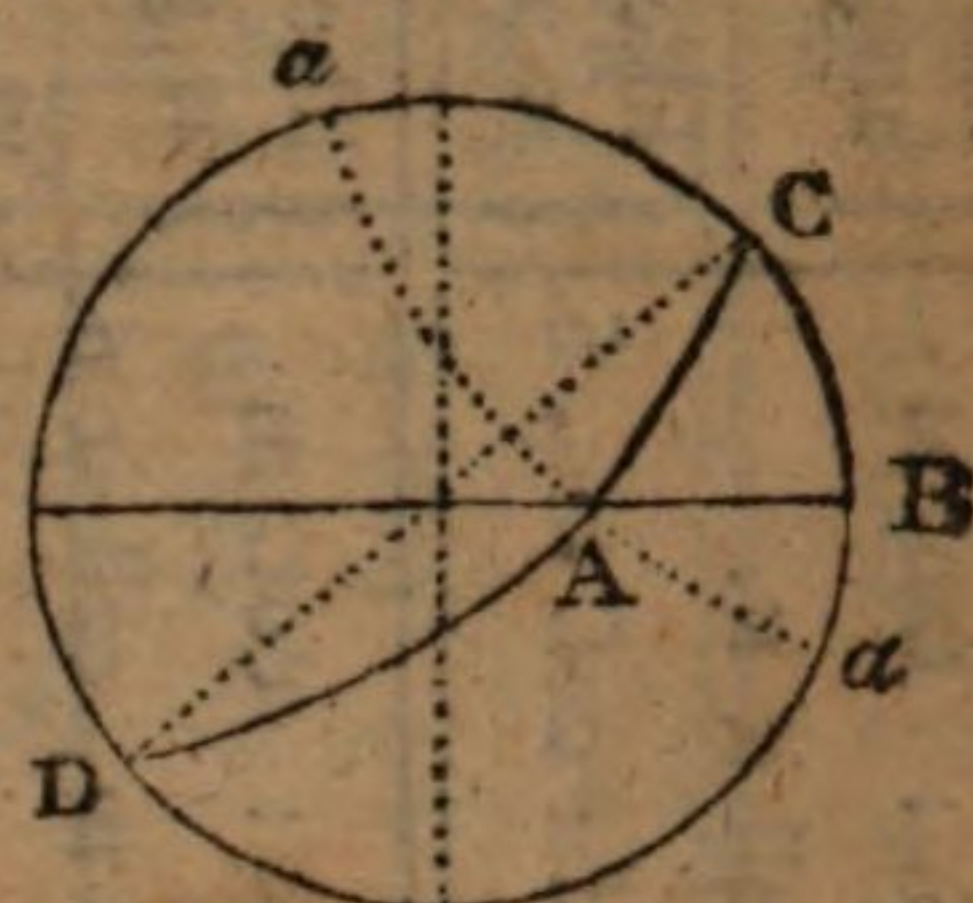
2. *To put the required leg on the primitive circle.*

Describe the primitive circle, and draw the right circle CB; on which lay the given leg ($42^\circ 12'$) from B to c. (446)

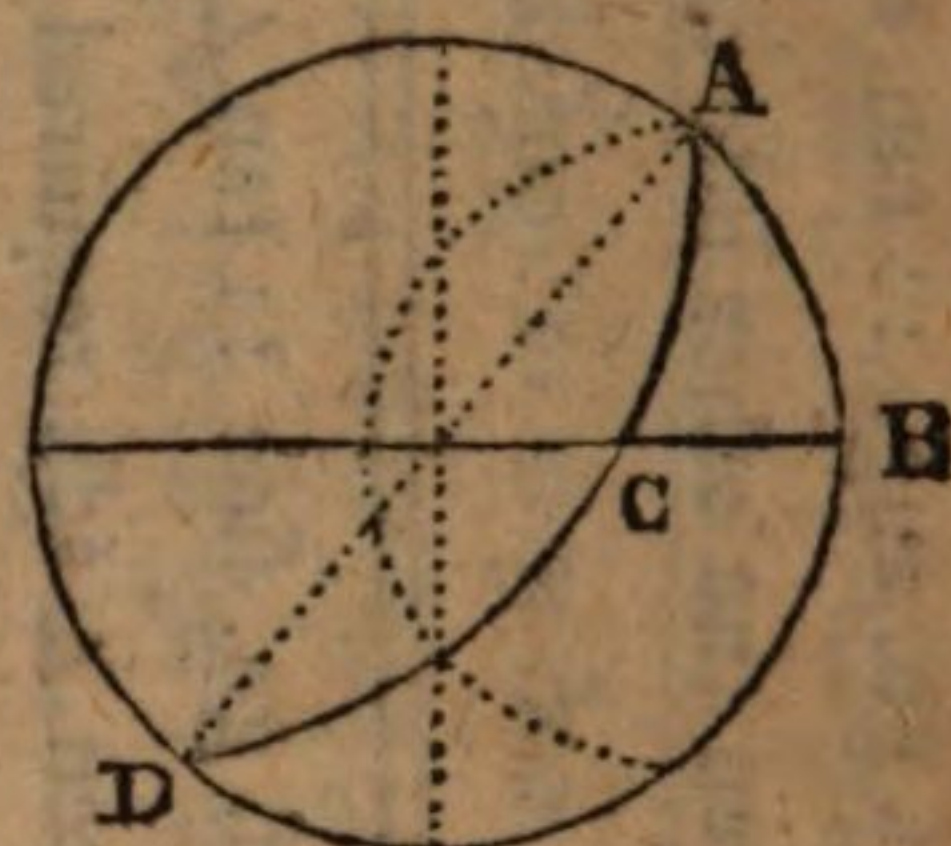
About c as a pole (454), at a distance equal to the hypoth. ($64^\circ 40'$) describe a small circle, cutting the primitive in A; and draw AD.

Thro' A, c, D, describe an oblique circle. (163)

Then ABC is the triangle required: Whose sides and angles are measured by art. 446, 448.



(163)



COMPUTATIONS.

<i>To find $\angle$ oppos. the giv. leg. (510)</i>			<i>To find $\angle$ adj. the given leg. (511)</i>		
As sin. hyp.	$= 64^\circ 40'$	0,04392	As Rad	$= 90^\circ 00'$	10,00000
To Rad	$= 90^\circ 00'$	10,00000	To cot. hyp.	$= 64^\circ 40'$	9,67524
So sin. gn. leg	$= 42^\circ 12'$	9,82719	So tan. gn. leg	$= 42^\circ 12'$	9,95748
To sin. op. $\angle$	$= 48^\circ 00'$	9,87111	To cos. adj. $\angle$	$= 64^\circ 35'$	9,63272

This angle is acute, because it is to be like the given leg, which is acute.

This angle is acute, because the hyp. and given legs are of like kinds.

<i>To find the other leg. (512)</i>		
As cos. gn. leg	$= 42^\circ 12'$	0,13030
To Rad	$= 90^\circ 00'$	10,00000
So cos. hyp.	$= 64^\circ 40'$	9,63133
To cos. req. leg	$= 54^\circ 43'$	9,76163

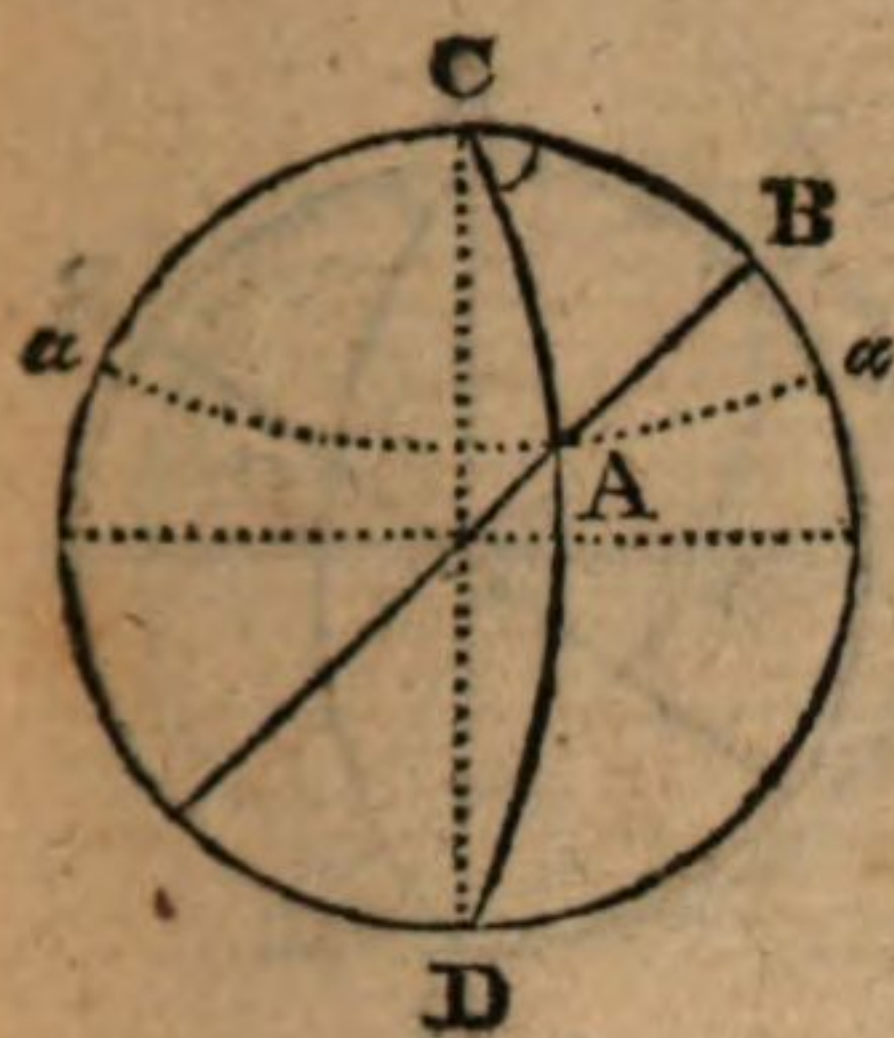
This leg is acute, because the hyp. and given leg are of like kinds.

NOTE. In these operations, and in all the following ones; altho' the cosine, or cotang, are used in the proportions; yet the degrees and min. set down, are not the complements, but the real sides or angles.

540. EXAM. II. In the right angled spheric triangle ABC,
 Given the hypoth. $AC = 64^{\circ} 40'$
 And one angle $ACB = 64^{\circ} 35'$ } Required the rest.

CONSTRUCTIONS.

1st. To put the leg adjacent to the given angle on the primitive circle.



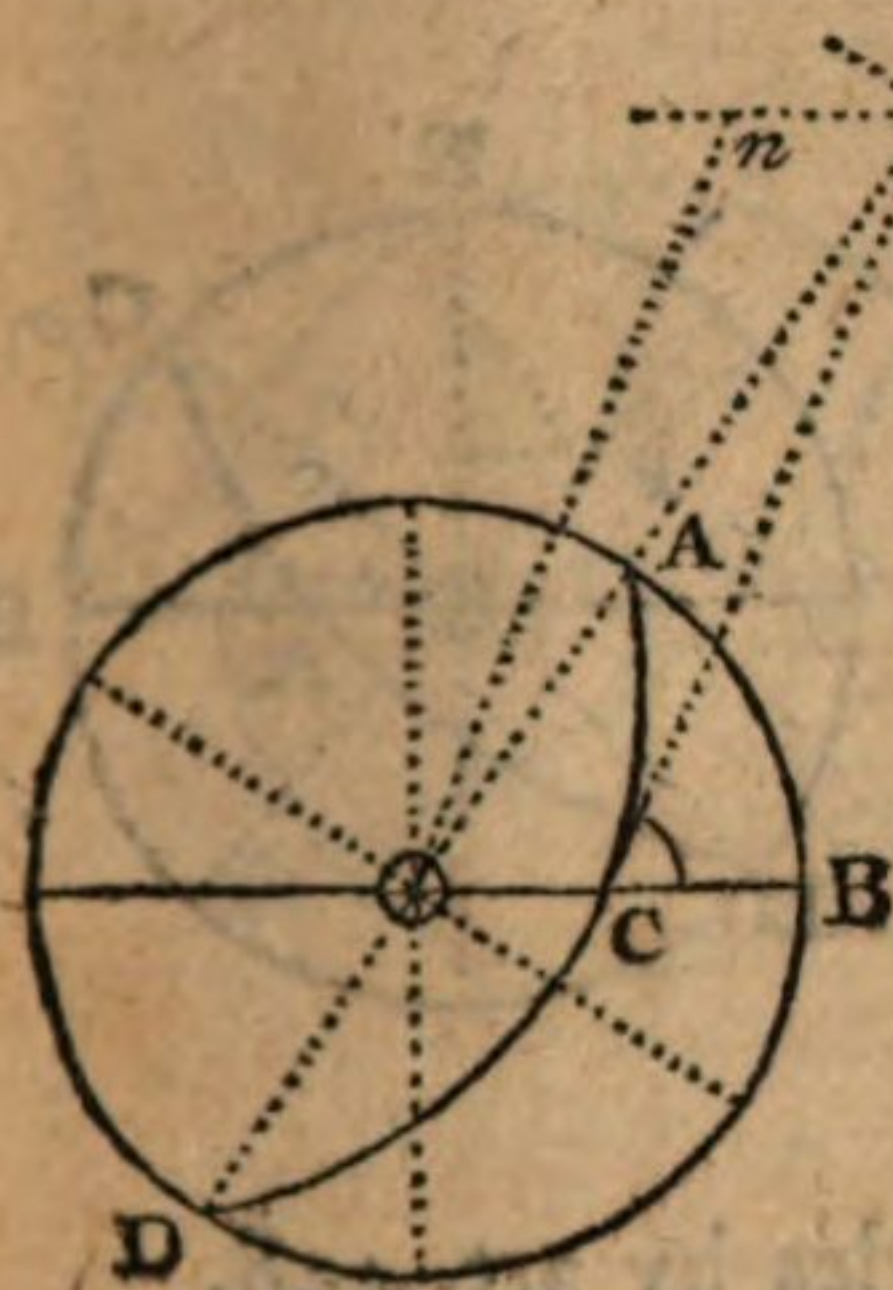
Thro' any point c, in the primitive circle, describe (451) the oblique circle CAD, making with the primitive circle the angle BCA equal to the given angle $64^{\circ} 35'$.

In the oblique circle CAD, take CA, equal to the given hypotenuse $64^{\circ} 40'$. (446)

Thro' A describe the right circle AB.

And CAB is the triangle required.

2d. To put the leg opposite the given angle on the primitive circle.



Having described the primitive circle, and drawn the right circle OB.

Describe (460) an oblique circle ACD, cutting the right circle OB in c, with the given angle $64^{\circ} 35'$, and having the part AC intercepted between the right circle OB and the primitive circle, equal to the given hypotenuse $64^{\circ} 40'$.

Then ABC is the triangle required.

The sides required are measured by art. 446.
 And the required angle by art. 448.

COMPUTATIONS.

To find the leg opp. the giv. $\angle$. (513)

As Rad	$= 90^{\circ} 00'$	10,00000
To fin. hyp.	$= 64^{\circ} 40'$	9,95608
So fin. given $\angle$	$= 64^{\circ} 35'$	9,95579

To fin. op. leg	$= 54^{\circ} 43'$	9,91187
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Like the given angle.

To find the leg adj. the giv. $\angle$. (414)

As Rad	$= 90^{\circ} 00'$	10,00000
To tan. hyp.	$= 64^{\circ} 40'$	10,32476
So cof. giv. $\angle$	$= 64^{\circ} 35'$	9,63266

Totan. adj. leg	$= 42^{\circ} 12'$	9,95742
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Acute, as the hypoth. and given angle are of like kind.

To find the other angle. (515)

As Rad	$= 90^{\circ} 00'$	10,00000
To cof. hyp.	$= 64^{\circ} 40'$	9,63133
So tan. given angle	$= 64^{\circ} 35'$	10,32313

To cot. required angle	$= 48^{\circ} 00'$	9,95446
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And is acute, as the hypoth. and given angle are of like kind.

541. EXAM. III. In the right angled spheric triangle ABC.
 Given one leg CB = $42^{\circ} 12'$
 And its opp. angle CAB = $48^{\circ} 00'$ } Required the rest.

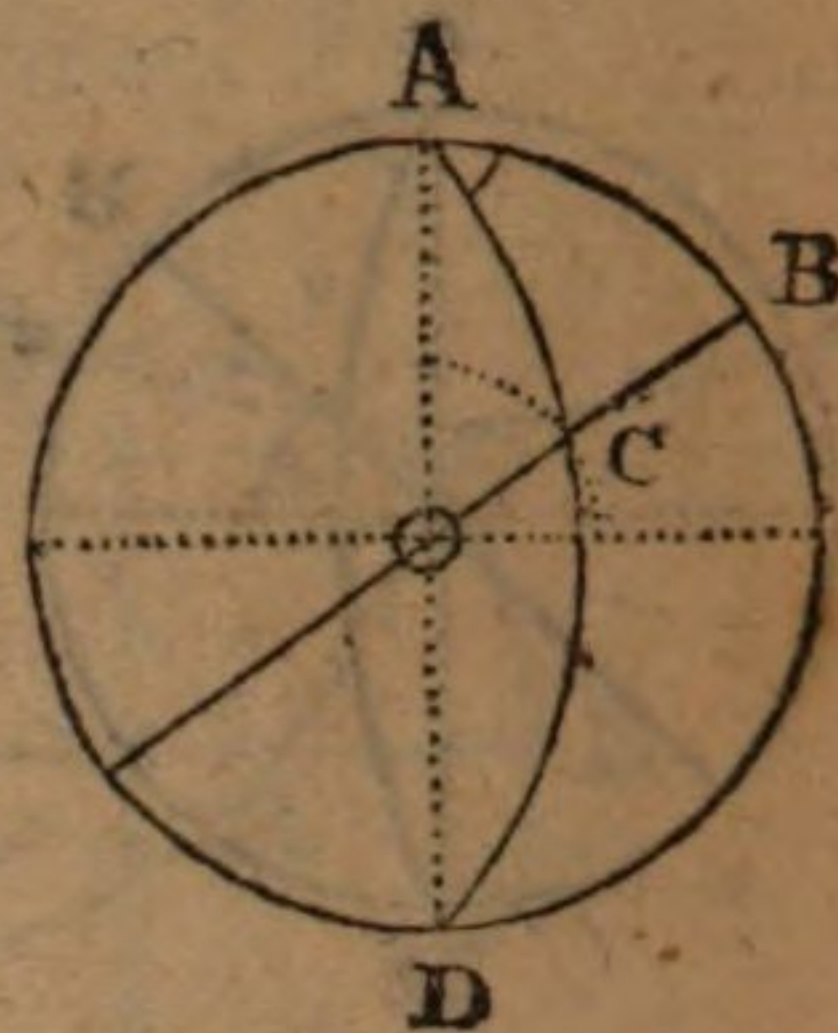
CONSTRUCTIONS.

1st. To put the required leg on the primitive circle.

Describe an oblique circle ACD (451), making with the primitive circle the angle CAB, equal to the given angle $48^{\circ} 00'$.

About the centre O of the primitive circle, describe (455) a small circle, at the distance of the complement of the given leg $42^{\circ} 12'$, cutting ACD in C.

Draw the right circle OCB, and ACB is the triangle sought.



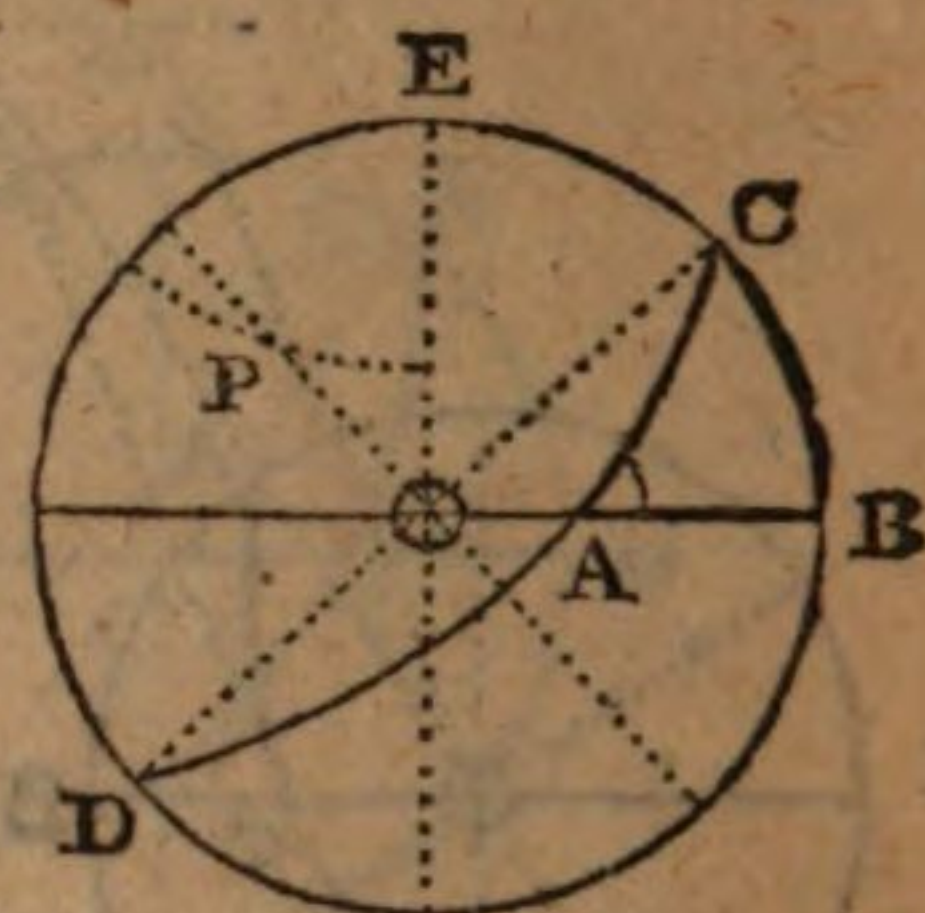
2d. To put the given leg on the primitive circle.

Draw the right circle OAB, and another OE at right angles.

Make BC equal to the given leg $42^{\circ} 12'$; draw the diameter CD, and another OP at right angles.

About E, the pole of AB, describe a small circle (456), at the distance of the given angle $48^{\circ} 00'$, cutting OP in P.

About P, as a pole (442), describe the oblique circle CAD, cutting AB in A: Then is CBA the triangle required.



The sides are measured by art. 446, and the angles by art. 448.

COMPUTATIONS.

To find the hypotenuse. (516)	
As fin. giv. $\angle = 48^{\circ} 00'$	0,12893
To fin. giv. leg = 42 12	9,82719
So Rad = 90 00	10,00000
To fin. hyp. = 64 $40\frac{1}{2}$	9,95612

And is either acute or obtuse.

To find the other leg. (517)	
As Rad = $90^{\circ} 00'$	10,00000
To cot. giv. $\angle = 48^{\circ} 00'$	9,95444
So tan. giv. leg = 42 12	9,95748
To fin. req. leg = 54 44	9,91192

And is either acute or obtuse.

To find the other angle. (518)

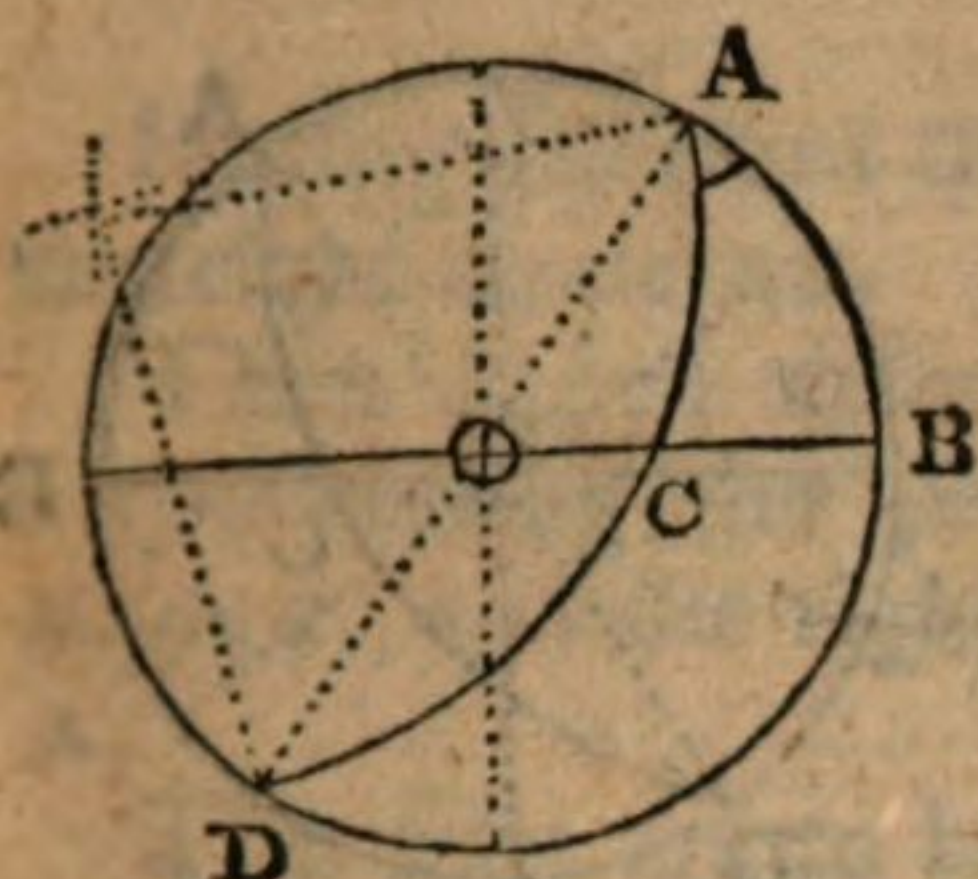
As cof. given leg	—	= $42^{\circ} 12'$	0,13030
To cof. given $\angle$	—	= $48^{\circ} 00'$	9,82551
So Rad	—	= $90^{\circ} 00'$	10,00000
To fin. required $\angle$	—	= 64 35	9,95581

And is either acute or obtuse.

542. EXAM. IV. In the right angled spheric triangle ABC.
 Given a leg $AC = 54^{\circ} 43'$
 And its adja. angle $CAB = 48^{\circ} 00'$ } Required the rest.

CONSTRUCTIONS.

1st. To put the given leg on the primitive circle.



Having described the primitive, and right circle OB.

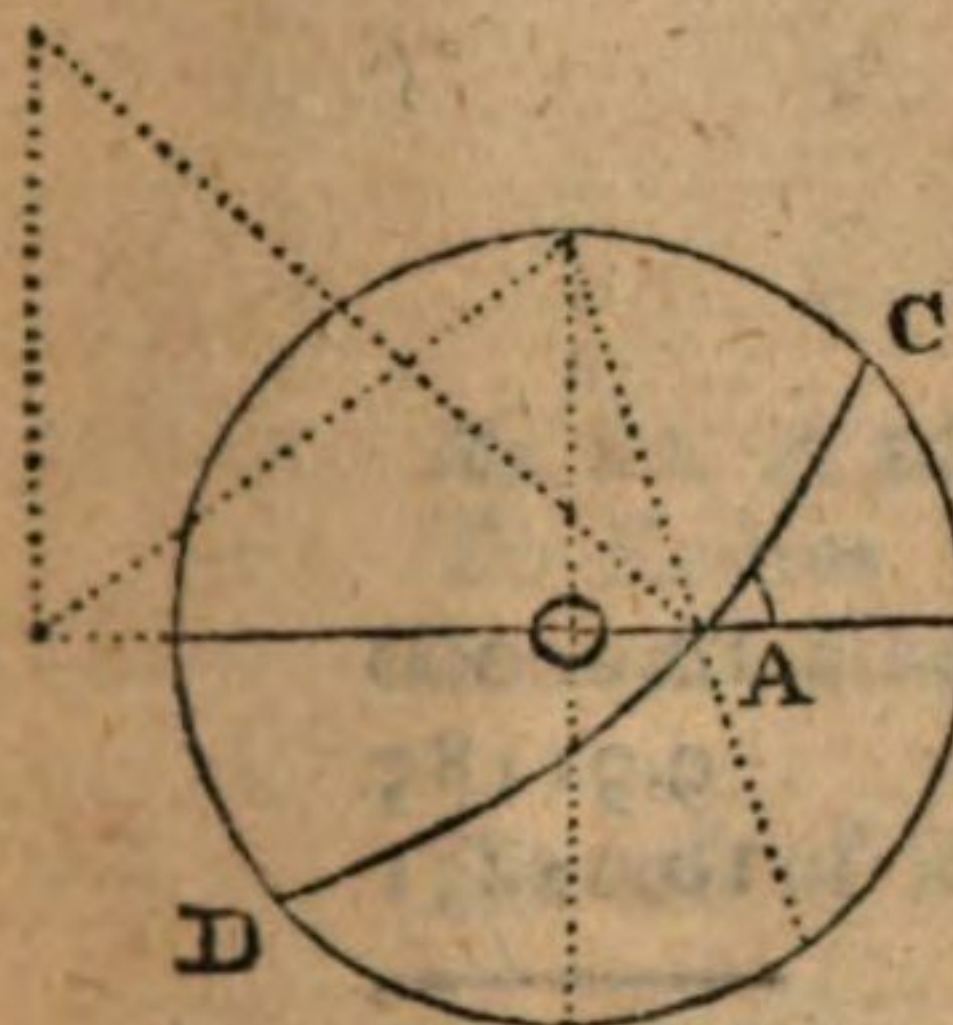
Make BA equal to the given leg $54^{\circ} 43'$.

Draw the diameter AD.

Thro' A describe the oblique circle ACD (451) making with the primitive the given angle BAC $48^{\circ} 00'$, cutting OB in C.

Then is ACB the triangle required

2d. To put the required leg on the primitive.



In the right circle OB, take (447) AB, equal to the given leg $54^{\circ} 43'$.

Thro' the point A, describe (452) the oblique circle CAD, making with AB the angle BAC, equal to the given angle $48^{\circ} 00'$, cutting the primitive circle in C.

Then is ABC the triangle sought.

The sides required are measured by art. 446.

And the required angle by art. 448.

COMPUTATIONS.

To find the other angle.

(519)

As Rad	$= 90^{\circ} 00'$	10,00000
To cof. giv. leg.	$= 54 \ 43$	9,76164
So sin. giv. $\angle$	$= 48 \ 00$	9,87107
To cof. req. $\angle$	$= 64 \ 35$	9,63271

And is like the given angle.

To find the other leg.

(520)

As Rad	$= 90^{\circ} 00'$	10,00000
To sin. giv. leg	$= 54 \ 43$	9,91185
So tan. giv. $\angle$	$= 48 \ 00$	10,04556
To tan. req. leg	$= 42 \ 12$	9,95741

And is like the given leg.

To find the hypotenuse. (521)

As Rad	$= 90^{\circ} 00'$	10,00000
To cof. given $\angle$	$= 48 \ 00$	9,82551
So cot. given leg	$= 54 \ 43$	9,84979
To cot. hyp.	$= 64 \ 40$	9,67530

And is acute, as the given leg and angle are of a like kind.

543. EXAM. V. In the right angled spheric triangle ABC.

Given one leg $BA = 54^\circ 43'$
 And the other leg $BC = 42^\circ 12'$ } Required the rest.

CONSTRUCTION.

To put either leg on the primitive circle.

Having described the primitive circle, and drawn the right circle OB.

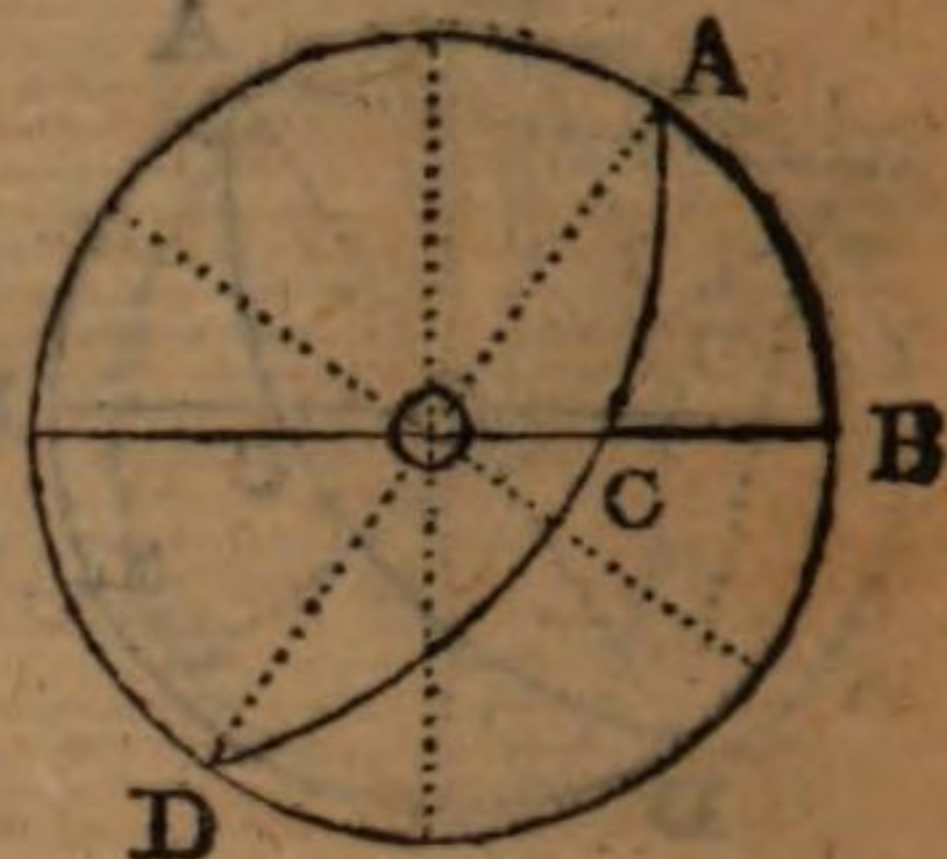
Then let the given legs $54^\circ 43'$, and $42^\circ 12'$, be applied, one from B to A, and the other from B to C (450); and draw the diameter AD.

Thro' the points A, C, D, describe an oblique circle. (163)

Then is ABC the triangle required.

The angles A and C may be measured by art. 448.

And the hypotenuse AC by art. 446.



COMPUTATIONS.

To find the angle A. (522)

As Radius	—	=	$90^\circ 00'$	10,00000
To sin. of leg AB	—	=	$54^\circ 43'$	9,91185
So cot. other leg BC	—	=	$42^\circ 12'$	10,04251
To cot. op. angle A	—	=	$48^\circ 00'$	9,95436

And is acute, as the opposite leg CB is acute.

To find the angle C. (522)

As Radius	—	=	$90^\circ 00'$	10,00000
To sin. of leg CB	—	=	$42^\circ 12'$	9,82719
So cot. other leg AB	—	=	$54^\circ 43'$	9,84979
To cot. op. angle C	—	=	$64^\circ 35'$	9,67698

And is acute, because the opposite leg AB is acute.

To find the hypotenuse AC. (523)

As Radius	—	=	$90^\circ 00'$	10,00000
To cos. either leg AB	—	=	$54^\circ 43'$	9,76164
So cos. other leg CB	—	=	$42^\circ 12'$	9,86970
To cos. hypoth. AC	—	=	$64^\circ 40'$	9,63134

And is acute, as the legs are of the same kind.

544. EXAM. VI. In the right angled spheric triangle ABC.
 Given one angle $A = 48^{\circ} 00'$
 And the other angle $c = 64^{\circ} 35'$ } Required the rest.

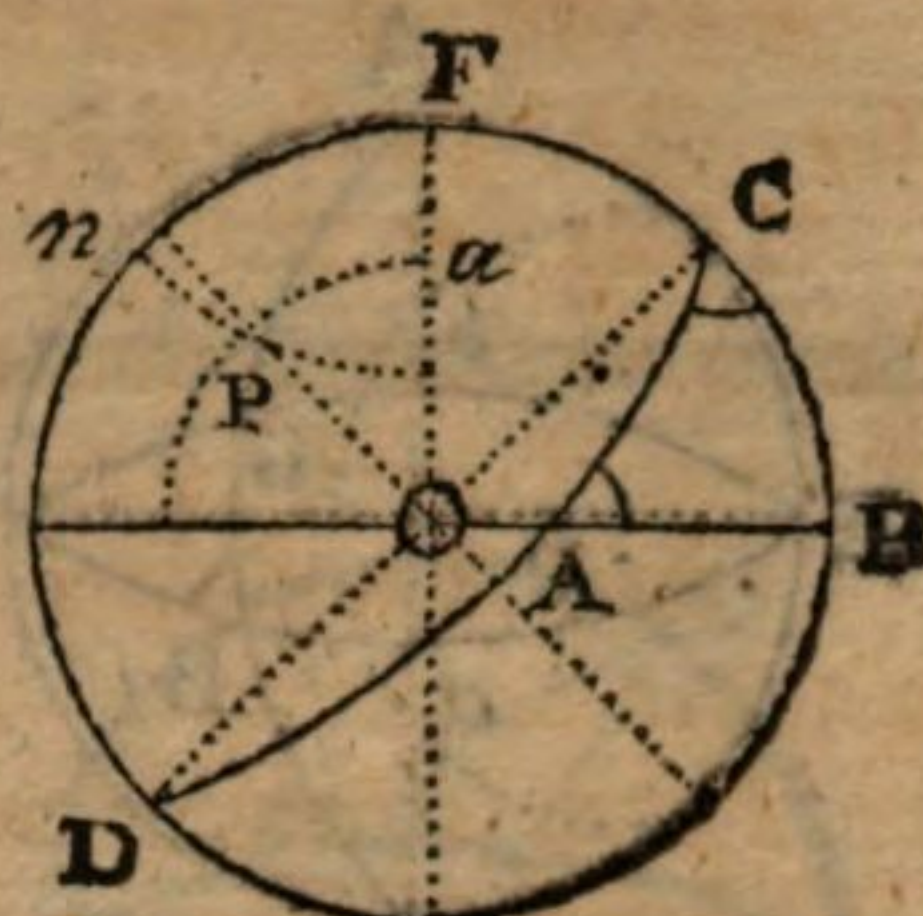
CONSTRUCTION.

To put either leg, as CB, on the primitive circle.

Having described the primitive circle, and drawn the right circle OB.

Then (461) describe the oblique great circle CAD, cutting the primitive circle in the given angle c, and the right circle OB in the given angle A.

The sides are to be measured by art. 446.



COMPUTATIONS.

To find the leg CB. (524)

As fin. $\angle$ adj. req. leg, c	$= 64^{\circ} 35'$	0,04421
To Radius	$= 90^{\circ} 00'$	10,00000
So cos. other angle A	$= 48^{\circ} 00'$	9,82551
To cos. of its op. leg CB	$= 42^{\circ} 12'$	9,86972

And is acute, because the opposite $\angle$ is acute.

To find the leg AB. (524)

As fin. $\angle$ adj. req. leg, A	$= 48^{\circ} 00'$	0,12893
To Radius	$= 90^{\circ} 00'$	10,00000
So cos. other angle c	$= 64^{\circ} 35'$	9,63266
To cos. of its op. leg AB	$= 54^{\circ} 43'$	9,76159

And is acute, because the opposite $\angle$ is acute.

To find the hypotenuse AC. (525)

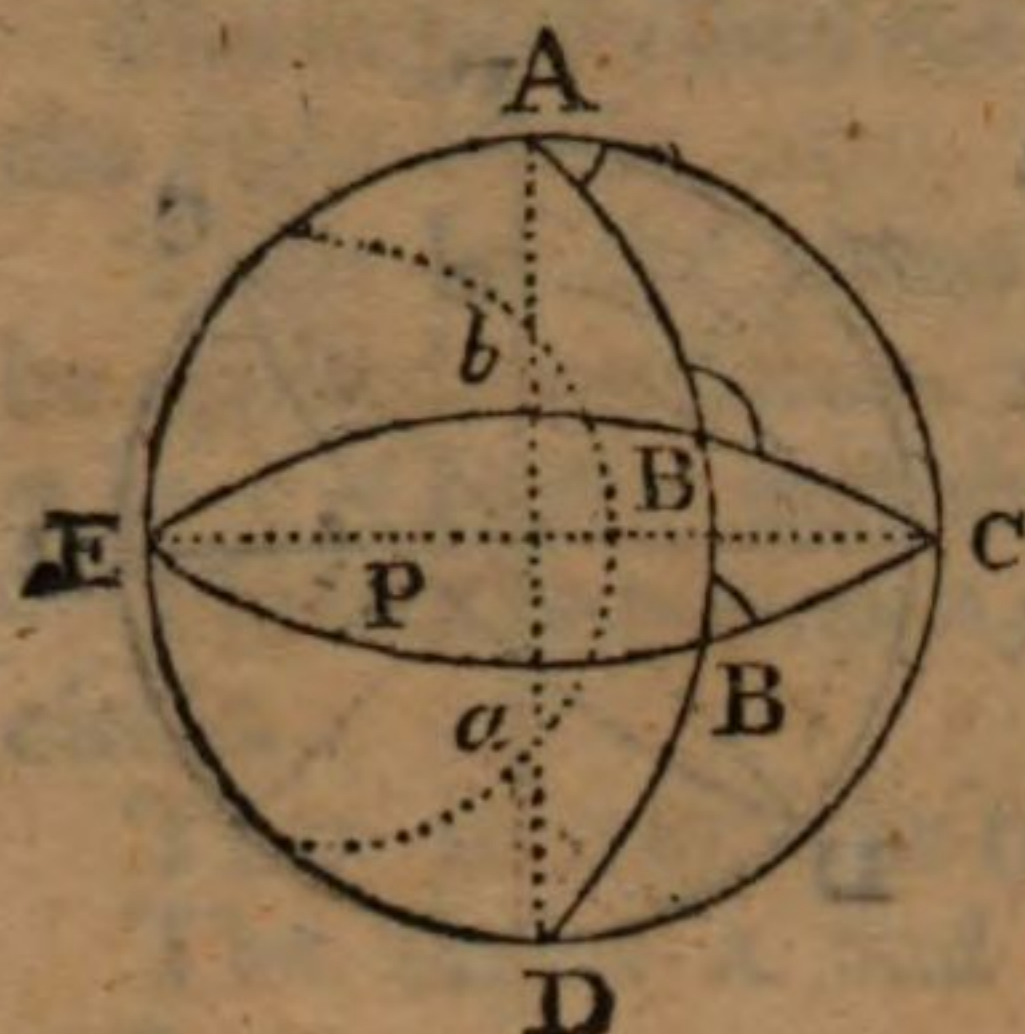
As Radius	$= 90^{\circ} 00'$	10,00000
To cot. either angle, as A	$= 48^{\circ} 00'$	9,95444
So cot. other angle, as c	$= 64^{\circ} 35'$	9,67687
To cos. hypoth. AC	$= 64^{\circ} 40'$	9,63131

And is acute, because the angles are both acute, or alike.

545. EXAM. VII. In the quadrantal triangle ABC.
 Given the quadrantal side $AC = 90^\circ 00'$
 An adjacent angle $A = 42^\circ 12'$
 And the opposite angle $B = 64^\circ 40'$ } Required the rest.

CONSTRUCTION.

To put the quadrantal side on the primitive circle.



Having described the primitive circle, and drawn the diameters AD, EC, at right angles.

Describe the oblique circle ABD, making with AC an angle of $42^\circ 12'$. (451)

Thro' c describe a great circle CBE, cutting the circle ABD in an $\angle$ of $64^\circ 40'$. (450)

Then is ABC the triangle sought.

The angle c is to be measured by art. 448.

And the sides AB, CB are measured by art. 446.

COMPUTATION.

Imagine the given triangle ABC to be changed into a right angled triangle, where the supplement of the angle B is to represent the hypotenuse, and the angle A to be one of the legs.

Then will the solution fall under art. 510, 511, 512, in the table; and the numeral computations will be the same as in Ex. I. Observing that the angles there found are, in this example, the measures of the sides AB, CB; and the side AB in that example stands for the angle c in this.

Now in determining the value of the parts of this triangle, as they arise in the computation; the words like and unlike are to be changed one for the other, where the hypotenuse is concerned in the determination: Thus the leg AB is taken acute, because the supplement of the angle opposite to the quadrantal side, which is here used as the hypotenuse, is unlike to the other given angle; and its opposite angle c is to be acute for the same reason: But the kind of the side BC being known by the kind of its opposite angle A, it must be taken acute, as the opposite angle is acute.

In the construction there arises two triangles, either of which will answer the conditions in the example: For the small circle described about P, the pole of the oblique circle ABD, cuts the diameter AD in the points a, b; and either of these points may be taken for the pole of the oblique circle wanting to compleat the triangle.

Now if a be taken for the pole, then in the triangle ABC, the measure of the things sought, will be equal to those arising from the computation: But the angle B is the supplement of what is given.

And if b is taken for the pole; then the triangle ABC will arise from the construction; wherein the angles A and B are respectively equal to what is propounded: But then the side AB, and the angle c, will both be obtuse.

SECTION IX.

The construction and numeral solution of the cases of oblique angled spheric triangles.

546. EXAM. I. In the oblique angled spheric triangle ABC.
 Given the side $AB = 114^{\circ} 30'$
 the side $BC = 56^{\circ} 40'$ } Required the rest.
 And an angle opposite to one side $BCA = 125^{\circ} 20'$

CONSTRUCTION.

To put the given side, adjacent to the known angle, on the primitive circle.
 Describe the primitive circle, and draw the diameter BD.

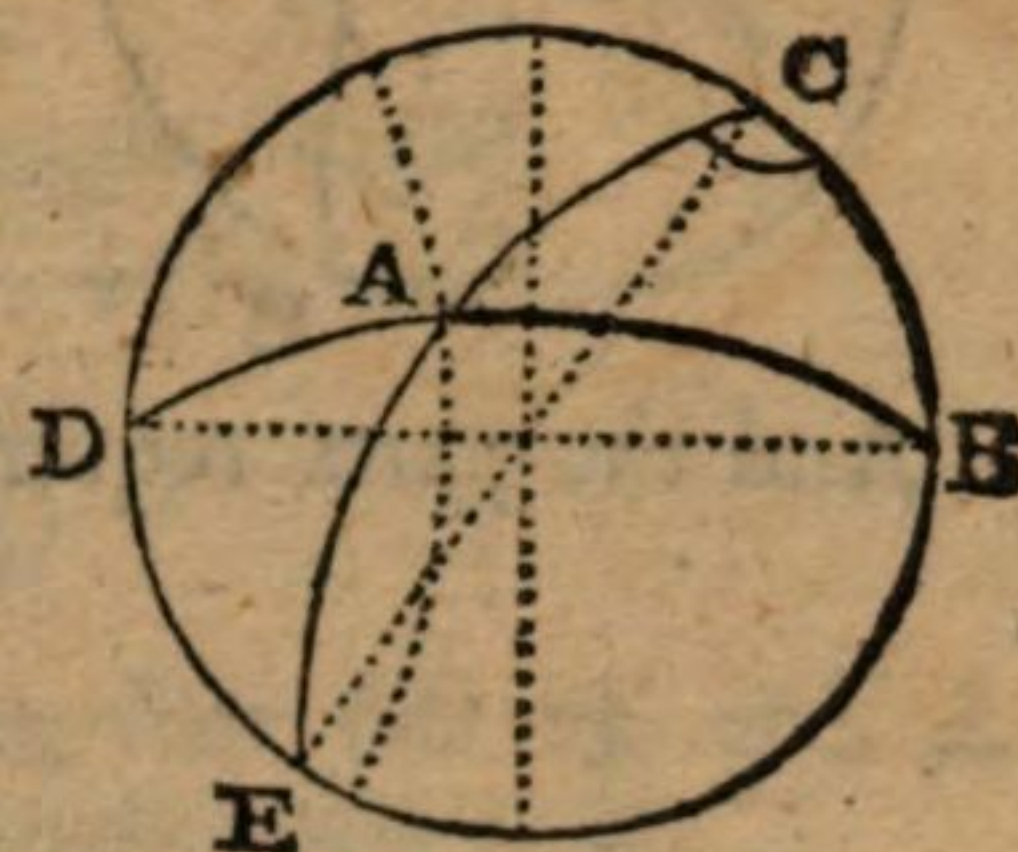
Make BC equal to the side adjacent to the given angle $= 56^{\circ} 40'$. (446)

Describe the great circle CAE, making the angle BCA equal to the given one, $= 125^{\circ} 20'$. (451)

Thro' B describe a great circle BAD, cutting CAE in A, at the distance of AB the other given side from B, $= 114^{\circ} 30'$. (456)

Then ABC is the triangle sought.

And the parts required are measured by art. 446, 448.



COMPUTATIONS.

To find the angle A, opposite to the other given side. (527)

As sin. one side $AB = 114^{\circ} 30'$	0,04098	} Which may be either acute or obtuse from the things given: But the construction shews it to be acute.
To sin. op. $\angle C = 56^{\circ} 40'$	9,92194	
So sin. oth. side $CB = 125^{\circ} 20'$	9,91158	
To sin. op. $\angle A = 48^{\circ} 31'$	9,87450	

To find the angle B between the given sides. (528)

As Rad	$= 90^{\circ} 00'$	10,00000	As cot. S. ad. g. $\angle C = 56^{\circ} 40'$	0,18196
To tan. giv. $\angle C = 125^{\circ} 20'$	10,14941		To cot. oth. side $AB = 114^{\circ} 30'$	9,65870
So cos. adj. sid. $BC = 56^{\circ} 40'$	9,73997		So cos. m	$= 127^{\circ} 46'$
To cot. m	$= 127^{\circ} 46'$	9,88938	To cos. n	$= 64^{\circ} 54'$
				9,62773

And is obtuse, as the given angle and its given adjacent side are unlike.

Which is acute, being unl. side opp. given $\angle$, that $\angle$ being obtuse.

Then as the given sides are unlike, the diff. of m and n, or $62^{\circ} 52' = \angle B$.

To find the other side AC. (529)

As Rad	$= 90^{\circ} 00'$	10,00000	As cos. S. ad. g. $\angle C = 56^{\circ} 40'$	0,26002
To cos. giv. $\angle C = 125^{\circ} 20'$	9,76218		To cos. oth. sid. $AB = 114^{\circ} 30'$	9,61773
So tan. adj. sid. $BC = 56^{\circ} 40'$	10,18196		So cos. M	$= 138^{\circ} 41'$
To tan. m	$= 138^{\circ} 41'$	9,94414	To cos. N	$= 55^{\circ} 28'$
				9,75343

And is obtuse, as $\angle C$ and CB are unlike.

And is acute, being unl. AB , as above.

Then as BC and BA are unlike, the diff. of M and N, or $83^{\circ} 13' = AC$.

547. EXAM. II. In the oblique angled spheric triangle ABC.

Given the angle
the angle

$$BAC = 48^{\circ} 31'$$

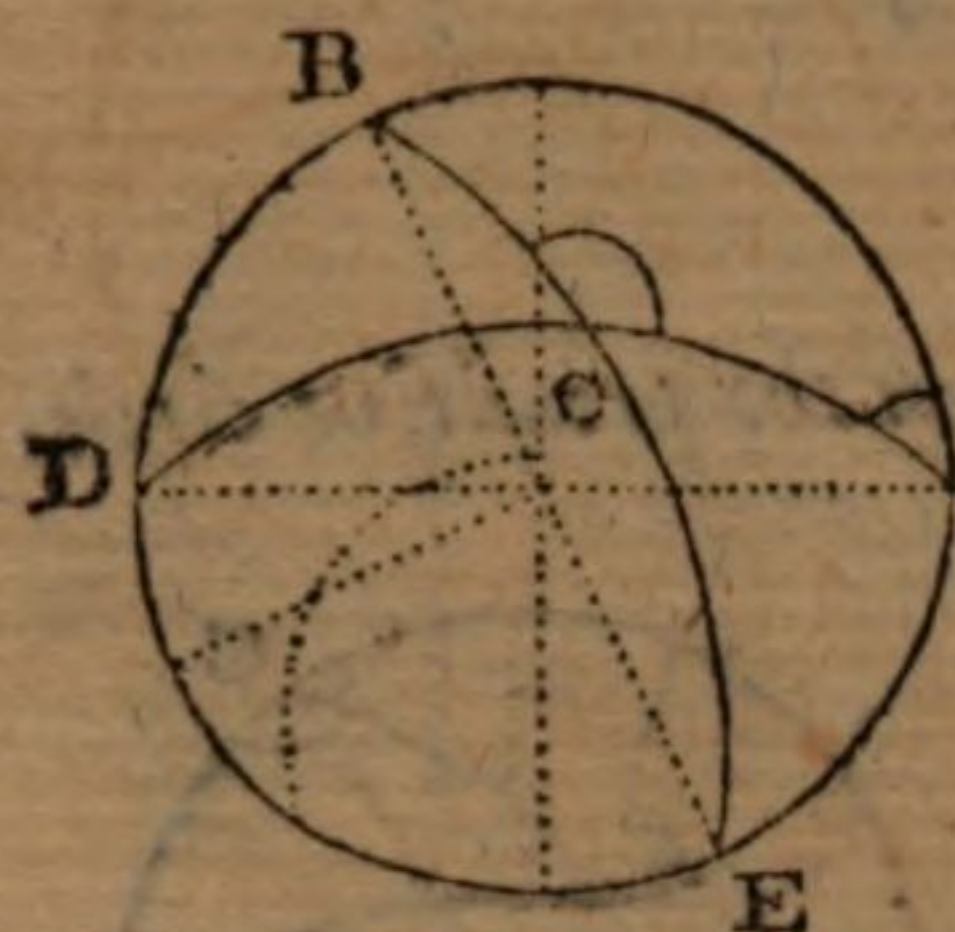
$$BCA = 125^{\circ} 20'$$

And the side opposite to one angle, $AB = 114^{\circ} 30'$

} Required the
rest.

CONSTRUCTION.

To put the given side AB on the primitive circle.



Describe the primitive circle, draw the diameter DA; and thro' A describe the great circle ACD, making the given angle $BAC = 48^{\circ} 31'$. (451)

Make the arc AB equal to the given side =

$114^{\circ} 30'$ (446); and draw the diam. BE.

Thro' B, describe the great circle BCE, cutting ACD in an angle equal to the given angle $BCA = 125^{\circ} 20'$. (458)

Then is ACB the triangle sought.

And the parts required are to be measured by art. 446, 448.

COMPUTATION.

To find the side opposite the other given angle. (530)

As sin. one $\angle C = 125^{\circ} 20'$ 0,08841

To sin. op. side AB = 114 30 9,87457

So sin. oth. $\angle A = 48^{\circ} 31'$ 9,95902

To sin. op. side BC = 56 40 9,92200

Which may be either acute or obtuse from what is given. But the construction shews it to be acute.

To find the side AC between the given angles. (531)

As Rad = $90^{\circ} 00'$ 10,00000

To cos. $\angle$ ad. g. S. A = $48^{\circ} 31'$ 9,82112

So tan. gn. S. AB = 114 30 10,34129

To tan. M = 124 32 10,16241

As cot $\angle$ ad. g. S. A = $48^{\circ} 31'$ 0,05345

To cot. oth. $\angle C = 125^{\circ} 20'$ 9,85059

So sine M = 124 32 9,91582

To sine N = 41 20 9,81986

And is obtuse, being unlike $\angle A$, as AB is greater than 90° .

Which may be either acute or obtuse; either $41^{\circ} 20'$, or $138^{\circ} 40'$.

Then as the given angles are unlike, the diff. of M and N, or $83^{\circ} 12'$, is the side AC.

To find the other angle ABC. (532)

As Rad = $90^{\circ} 00'$ 10,00000

To tan. $\angle$ ad. g. S. A = $48^{\circ} 31'$ 10,05319

So cos. g. side AB = 114 30 9,61773

To cot. m = 115 07 9,67092

As cos. $\angle$ ad. g. S. A = $48^{\circ} 31'$ 0,17888

To cos. oth. $\angle C = 125^{\circ} 20'$ 9,76218

So sine m = 115 07 9,95686

To sine n = 52 14 9,89792

And is obtuse, being unlike $\angle A$, as its adj. side AB is greater than 90° .

Which may be either acute or obtuse.

Then as the given angles are unlike, the diff. of m and n, or $62^{\circ} 53'$, is the angle B required.

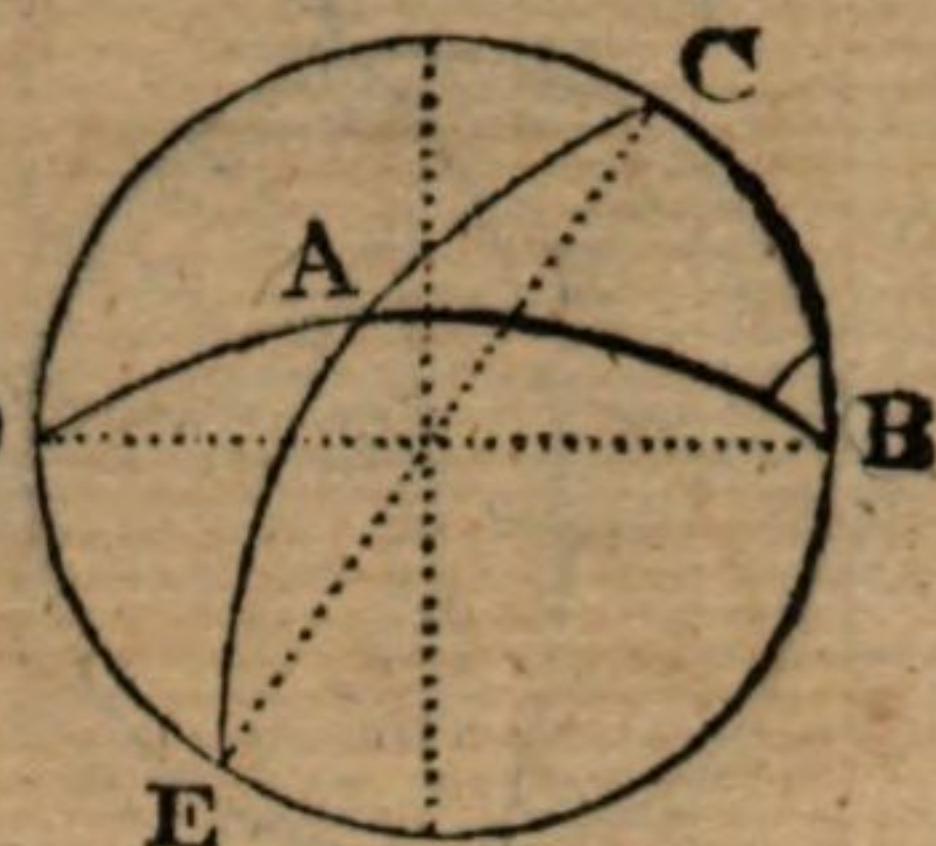
548. EXAM. III. In the oblique angled spheric triangle ABC.
 Given the side $AB = 114^{\circ} 30'$
 the side $BC = 56^{\circ} 40'$ } Required the rest.
 And the contained angle $ABC = 62^{\circ} 52'$

CONSTRUCTION.

To put either of the given sides, as BC, on the primitive circle.

Describe the primitive circle, draw the diameter BD; and thro' B describe a great circle BAD, making the given angle $ABC = 62^{\circ} 52'$.

(451) D



On the circles BCD, BAD, take the arcs BC, BA, respectively equal to the given sides, viz. $BC = 56^{\circ} 40'$, and $BA = 114^{\circ} 30'$. (446)

Draw the diameter CE, and thro' C, A, E, describe the great circle CAE; then ABC is the triangle sought.

The required parts of ABC are measured by art. 446, 448.

COMPUTATION.

To find the angle C. (533)

As Rad	$= 90^{\circ} 00'$	10,00000	} Obtuse, being like side op. req. $\angle$; The given angle being acute. Take the diff. between M and BC, and 'tis $78^{\circ} 19'$, call it N.
To cos. gn. $\angle B$	$= 62^{\circ} 52'$	9,65902	
Sot. S.op.re. $\angle AB$	$= 114^{\circ} 30'$	10,34129	
To tan. M	$= 134^{\circ} 59'$	10,00031	} And is obtuse, being unlike the given angle, because M is greater than BC, the side adjacent to the required angle.
As fine N	$= 78^{\circ} 19'$	0,00909	
To fine M	$= 134^{\circ} 59'$	9,84961	
So tan. gn. $\angle B$	$= 62^{\circ} 52'$	10,29034	
To tan. req. $\angle C$	$= 125^{\circ} 21'$	10,14904	

To find the angle A. (533)

As Rad	$= 90^{\circ} 00'$	10,00000	} Acute, being like side op. req. $\angle$. The given angle being acute. Take the diff. between M and BA, and 'tis $79^{\circ} 46'$, call it N.
To cos. gn. $\angle B$	$= 62^{\circ} 52'$	9,65902	
Sot. S.op.re. $\angle BC$	$= 56^{\circ} 40'$	10,18196	
To tan. of M	$= 34^{\circ} 44'$	9,84098	} And is acute, being like the given angle, as M is less than AB, the side adjacent to the required angle.
As fine N	$= 79^{\circ} 46'$	0,00696	
To fine M	$= 34^{\circ} 44'$	9,75569	
So tan. gn. $\angle B$	$= 62^{\circ} 52'$	10,29034	
To tan. req. $\angle A$	$= 48^{\circ} 29'$	10,05299	

To find the other side AC. (534)

As Rad	$= 90^{\circ} 00'$	10,00000	As cos. M	$= 134^{\circ} 59'$	0,15304
To cos. gn. $\angle B$	$= 62^{\circ} 52'$	9,65902	To cos. N	$= 78^{\circ} 19'$	9,30643
So tan. eith. S. AB	$= 114^{\circ} 30'$	10,34129	So cos. S. used AB	$= 114^{\circ} 30'$	9,61773
To tan. M	$= 134^{\circ} 59'$	10,00031	To cos. S. req. AC	$= 83^{\circ} 11'$	9,07480

Obtuse, being like AB the side used, because the given angle is acute.

And is acute, being like N; because the given angle is acute.

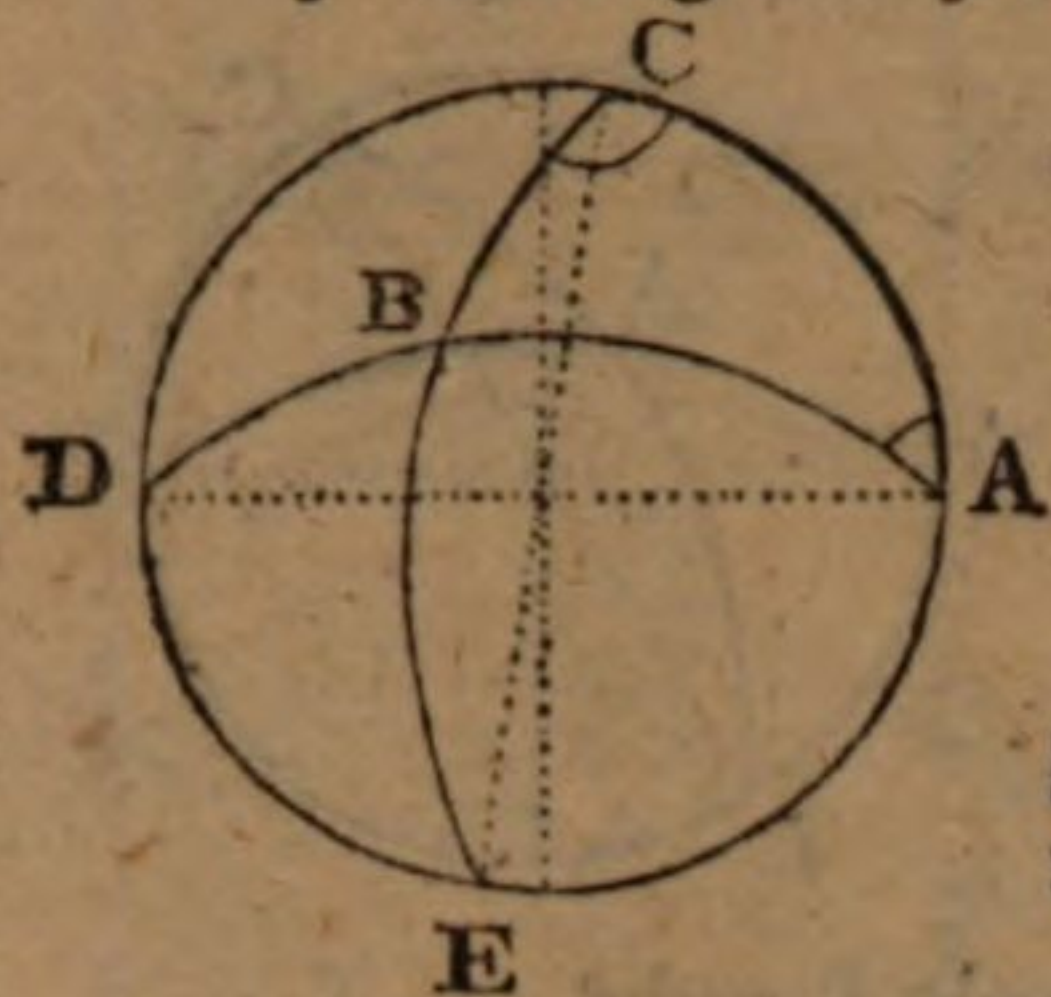
Then the diff. M and BC, or $78^{\circ} 19' = N$.

549. EXAM. IV. In the oblique angled spheric triangle ABC.

Given the angle $BCA = 125^\circ 20'$
 the angle $BAC = 48^\circ 31'$ } Required the rest.
 And the included side $AC = 83^\circ 13'$

CONSTRUCTION.

To put the given side on the primitive circle.



Describe the primitive circle, draw the diameter AD; and thro' A describe the great circle ABD, making the given $\angle BAC = 48^\circ 31'$. (451)

Make AC equal to the given side $= 83^\circ 13'$. (446)

Draw the diameter CE, and thro' c describe the great circle CBE, making the given angle $BCA = 125^\circ 20'$ (451), cutting ABD in B.

Then is ABC the triangle sought.

And the parts required are measured by art. 446, 448.

COMPUTATION.

To find the side AB. (535)

As Rad	$= 90^\circ 00' 10,00000$	} Obtuse, being like $\angle$ op. side req. the given side being acute.
To cos. gn. side AC	$= 83^\circ 13' 9,07230$	
So tan. $\angle$ op. r. S. c	$= 125^\circ 20' 10,14941$	
To cot. m.	$= 99^\circ 28' 9,22171$	} Take the diff. between m and $\angle$ A, and it is $50^\circ 57'$; call it n.
As cos. n	$= 50^\circ 57' 0,20066$	
To cos. m	$= 99^\circ 28' 9,21610$	} And is obtuse, being unlike n, because the angle opposite to the side required is obtuse.
So tan. gn. sid. AC	$= 83^\circ 13' 10,92464$	
To tan. req. sid. AB	$= 114^\circ 30' 10,34140$	

To find the side BC. (535)

As Rad	$= 90^\circ 00' 10,00000$	} Acute, being like $\angle$ op. side required, the given side being acute.
To cos. gn. sid. AC	$= 83^\circ 13' 9,07230$	
So tan. $\angle$ op. r. S. A	$= 48^\circ 31' 10,05345$	
To cot. of m	$= 82^\circ 23' 9,12575$	} Take the diff. between m and $\angle$ c; and 'tis $42^\circ 57'$, call it n.
As cos. n	$= 42^\circ 57' 0,13552$	
To cos. m	$= 82^\circ 23' 9,12236$	} And is acute; being like n; because the angle A opposite to BC, the side required, is acute.
So tan. gn. sid. AC	$= 83^\circ 13' 10,92464$	
To tan. req. sid. BC	$= 56^\circ 41' 10,18252$	

To find the other angle B. (536)

As Rad	$= 90^\circ 00' 10,00000$	As sin. m	$= 99^\circ 28' 0,00595$
To cos. gn. sid. AC	$= 83^\circ 13' 9,07230$	To sine n	$= 50^\circ 57' 9,89019$
So tan. eith. $\angle$ c	$= 125^\circ 20' 10,14941$	So cos. $\angle$ used, c	$= 125^\circ 20' 9,76218$
To cot. m	$= 99^\circ 28' 9,22171$	To cos. req. $\angle$ B	$= 62^\circ 53' 9,65832$

Obtnse, being like $\angle$ c here used: Because the given side is acute.

Take diff. of m and $\angle$ A, viz. $42^\circ 57'$, and call it n.

And is acute, being unlike the angle c here used, as m is greater than the other angle A.

550. EXAM. V. In the oblique angled spheric triangle ABC.

Given the side $AB = 114^\circ 30'$
 the side $AC = 83^\circ 13'$
 the side $BC = 56^\circ 40'$ } Required the rest.

CONSTRUCTION.

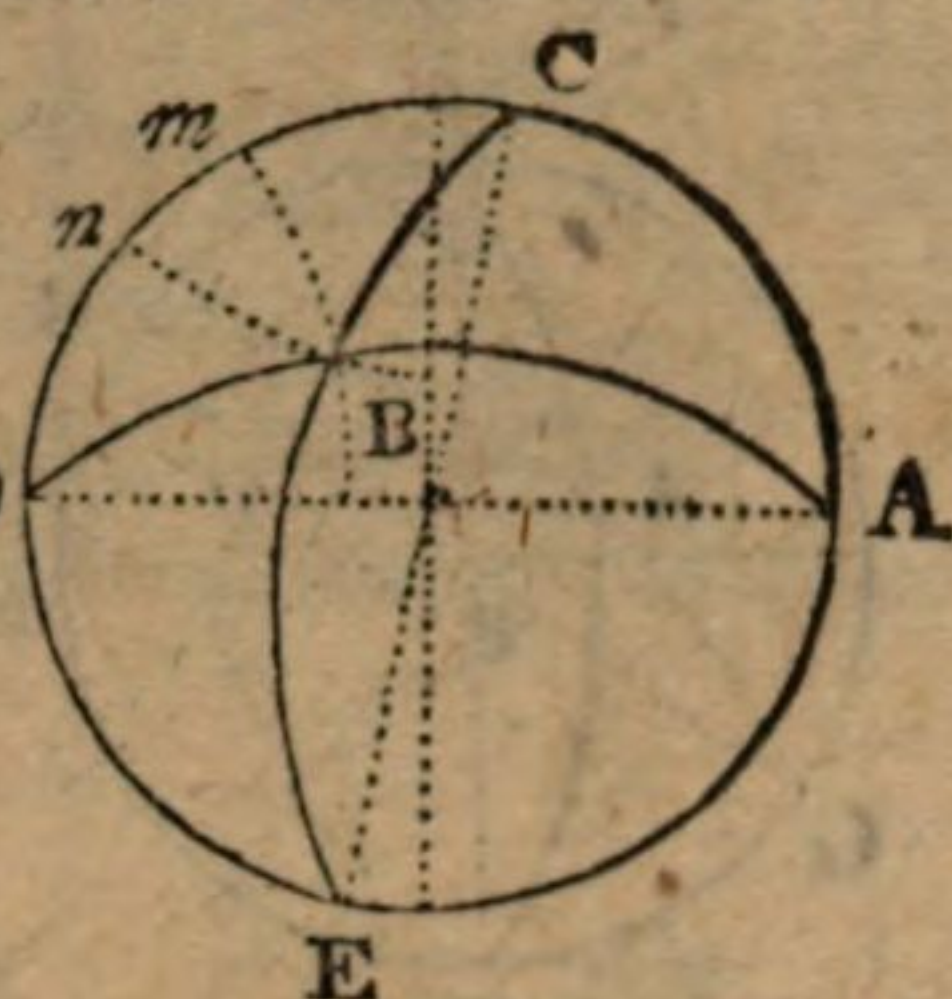
To put either side, as AC, on the primitive circle.

Describe the primitive circle, and from any point in the circumference, as A, set off one of the given sides, as AC, $= 83^\circ 13'$ (446); and draw the diameters AD, CE.

About C, as a pole, and at a distance equal to the given side BC, $= 56^\circ 40'$, describe a small circle nB . (456)

About A, as a pole, and at a distance equal to the given side AB (when AB is less than 90°) describe another small circle mB (456), cutting the former in B: But when the side, as $AB = 114^\circ 30'$, is greater than 90° ; then about D, the opposite pole to A, describe a small circle with the supplement of AB, as mB , cutting the former small circle nB in B.

Thro' the points A, B, D, and C, B, E, describe the great circles ABD, CBE. Then is ABC the triangle sought. And the angles are measured by art. 448.



COMPUTATION.

To find the angle C. (527.)

Here $AC = E = 83^\circ 13'$	Ar. Co. fin. E	$= 83^\circ 13' 0,00305$
$CB = F = 56^\circ 40'$	Ar. Co. fin. F	$= 56^\circ 40' 0,07806$
$AB = G = 114^\circ 30'$	Sin. $\frac{1}{2}$ sum	$= 70^\circ 31\frac{1}{2}' 9,97441$
$E - F = D = 26^\circ 33'$	Sin. $\frac{1}{2}$ diff.	$= 43^\circ 58\frac{1}{2}' 9,84158$
$C + D = 141^\circ 03'$	Sum of the four Logs	$19,89710$
$C - D = 87^\circ 57'$	$\frac{1}{2}$ sum gives $62^\circ 39\frac{1}{2}'$	$9,94855$
$70^\circ 31\frac{1}{2}' = \frac{1}{2}$ sum	Which doubled, gives $125^\circ 10' = \angle C$.	
$43^\circ 58\frac{1}{2}' = \frac{1}{2}$ diff.		

To find the angle A. (527)

Here $AB = E = 114^\circ 30'$	Ar. Co. fin. E	$= 114^\circ 30' 0,04098$
$AC = F = 83^\circ 13'$	Ar. Co. fin. F	$= 83^\circ 13' 0,00305$
$BC = G = 56^\circ 40'$	Sin. $\frac{1}{2}$ sum	$= 43^\circ 58\frac{1}{2}' 9,84158$
$E - F = D = 31^\circ 17'$	Sin. $\frac{1}{2}$ diff.	$= 12^\circ 41\frac{1}{2}' 9,34184$
$C + D = 87^\circ 57'$	Sum of four Logs	$19,22745$
$C - D = 25^\circ 23'$	$\frac{1}{2}$ sum gives $24^\circ 15\frac{1}{2}'$	$9,61372$
$43^\circ 58\frac{1}{2}' = \frac{1}{2}$ sum	Which doubled gives $48^\circ 31' = \angle A$.	
$12^\circ 41\frac{1}{2}' = \frac{1}{2}$ diff.		

To find the angle B. (527)

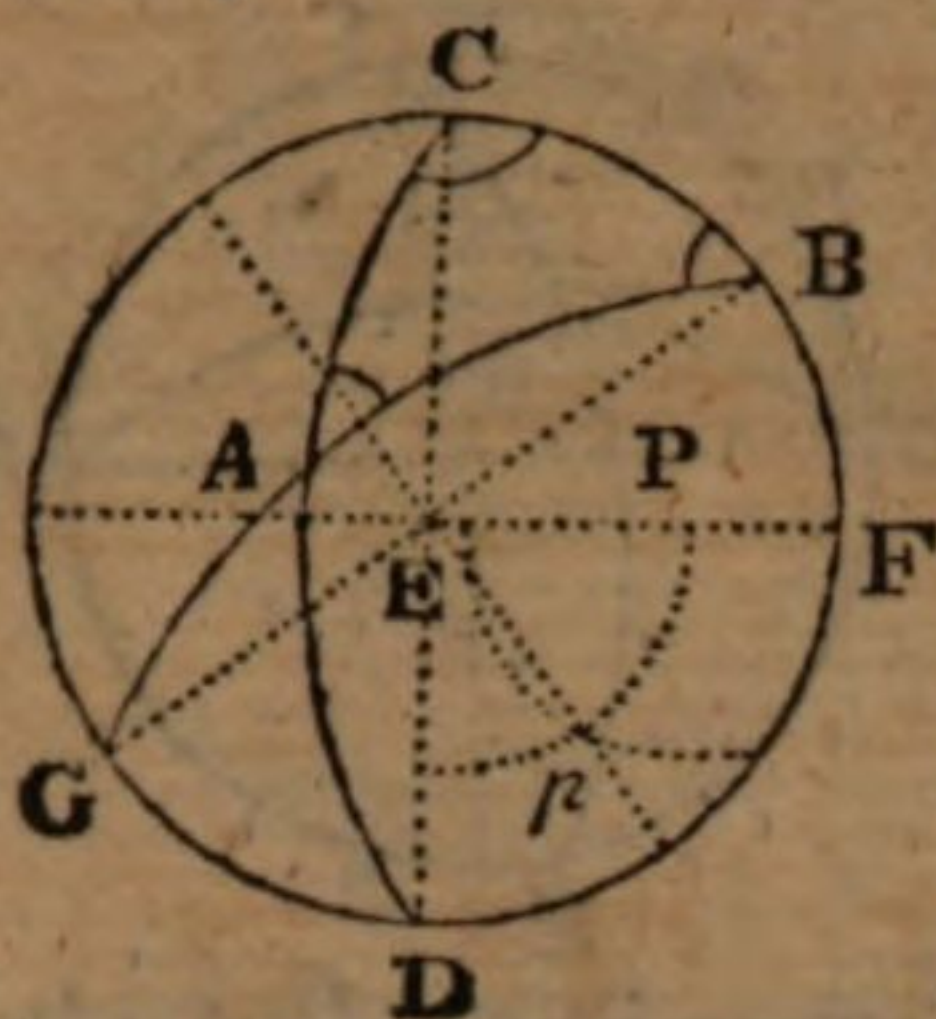
Here $AB = E = 114^\circ 30'$	Ar. Co. fin. E	$= 114^\circ 30' 0,04098$
$BC = F = 56^\circ 40'$	Ar. Co. fin. F	$= 56^\circ 40' 0,07806$
$AC = G = 83^\circ 13'$	Sin. $\frac{1}{2}$ sum	$= 70^\circ 31\frac{1}{2}' 9,97441$
$E - F = D = 57^\circ 50'$	Sin. $\frac{1}{2}$ diff.	$= 12^\circ 41\frac{1}{2}' 9,34184$
$C + D = 141^\circ 03'$	Sum of four Logs	$19,43529$
$C - D = 25^\circ 23'$	$\frac{1}{2}$ sum gives $31^\circ 28'$	$9,71764$
$70^\circ 31\frac{1}{2}' = \frac{1}{2}$ sum	Which doubled gives $62^\circ 56' = \angle B$.	
$12^\circ 41\frac{1}{2}' = \frac{1}{2}$ diff.		

551. EXAM. VI. In the oblique angled spheric triangle ABC.

Given the angle $A = 48^\circ 31'$
 the angle $B = 62^\circ 52'$
 the angle $C = 125^\circ 20'$ } Required the rest.

CONSTRUCTION.

To put either two angles, as C and B, at the primitive circle.



Describe the primitive circle, draw the diameters CD and EF at right angles to one another; and thro' c describe a great circle CAD, making the angle BCA equal to the given angle $C = 125^\circ 20'$ (451)

Describe a great circle BAG, cutting the given great circles CFD, CAD, in the given angles $B = 62^\circ 52'$, and $A = 48^\circ 31'$. (461)

Then is ABC the triangle sought.

Wherein the sides are measured by art. 446.

COMPUTATION.

To find the side AB. (528)

Here $\angle B = E = 62^\circ 52'$

$\angle A = F = 48^\circ 31'$

Sup. $\angle C = G = 54^\circ 40'$

$E - F = D = 14^\circ 21'$

$G + D = 69^\circ 01' \quad 34^\circ 30\frac{1}{2}' = \frac{1}{2} \text{ sum}$

$G - D = 40^\circ 19' \quad 20^\circ 09\frac{1}{2}' = \frac{1}{2} \text{ diff.}$

Ar. Co. fin. E $= 62^\circ 52' \quad 0,05064$

Ar. Co. fin. F $= 48^\circ 31' \quad 0,12543$

Sin. $\frac{1}{2}$ sum $= 34^\circ 30\frac{1}{2}' \quad 9,75322$

Sin. $\frac{1}{2}$ diff. $= 20^\circ 09\frac{1}{2}' \quad 9,53733$

Sum of the four Logs $19,46662$

$\frac{1}{2}$ sum gives $32^\circ 45\frac{1}{2}' \quad 9,73331$

The sup. of its double is $114^\circ 29' = AB$.

To find the side AC. (528)

Here $\angle C = E = 125^\circ 20'$

$\angle A = F = 48^\circ 31'$

Sup. $\angle B = G = 117^\circ 08'$

$E - F = D = 76^\circ 49'$

$G + D = 193^\circ 57' \quad 96^\circ 58\frac{1}{2}' = \frac{1}{2} \text{ sum}$

$G - D = 40^\circ 19' \quad 20^\circ 09\frac{1}{2}' = \frac{1}{2} \text{ diff.}$

Ar. Co. fin. E $= 125^\circ 20' \quad 0,08842$

Ar. Co. fin. F $= 48^\circ 31' \quad 0,12543$

Sin. $\frac{1}{2}$ sum $= 96^\circ 58\frac{1}{2}' \quad 9,99677$

Sin. $\frac{1}{2}$ diff. $= 20^\circ 09\frac{1}{2}' \quad 9,53733$

Sum of four Logs $19,74795$

$\frac{1}{2}$ sum gives $48^\circ 25\frac{1}{2}' \quad 9,87397$

The sup. of its double is $83^\circ 09' = CA$.

To find the side BC. (528)

Here $\angle C = E = 125^\circ 20'$

$\angle B = F = 62^\circ 52'$

Sup. $\angle A = G = 131^\circ 29'$

$E - F = D = 62^\circ 28'$

$G + D = 193^\circ 57' \quad 96^\circ 58\frac{1}{2}' = \frac{1}{2} \text{ sum}$

$G - D = 69^\circ 01' \quad 34^\circ 30\frac{1}{2}' = \frac{1}{2} \text{ diff.}$

Ar. Co. fin. E $= 125^\circ 20' \quad 0,08842$

Ar. Co. fin. F $= 62^\circ 52' \quad 0,05064$

Sin. $\frac{1}{2}$ sum $= 96^\circ 58\frac{1}{2}' \quad 9,99677$

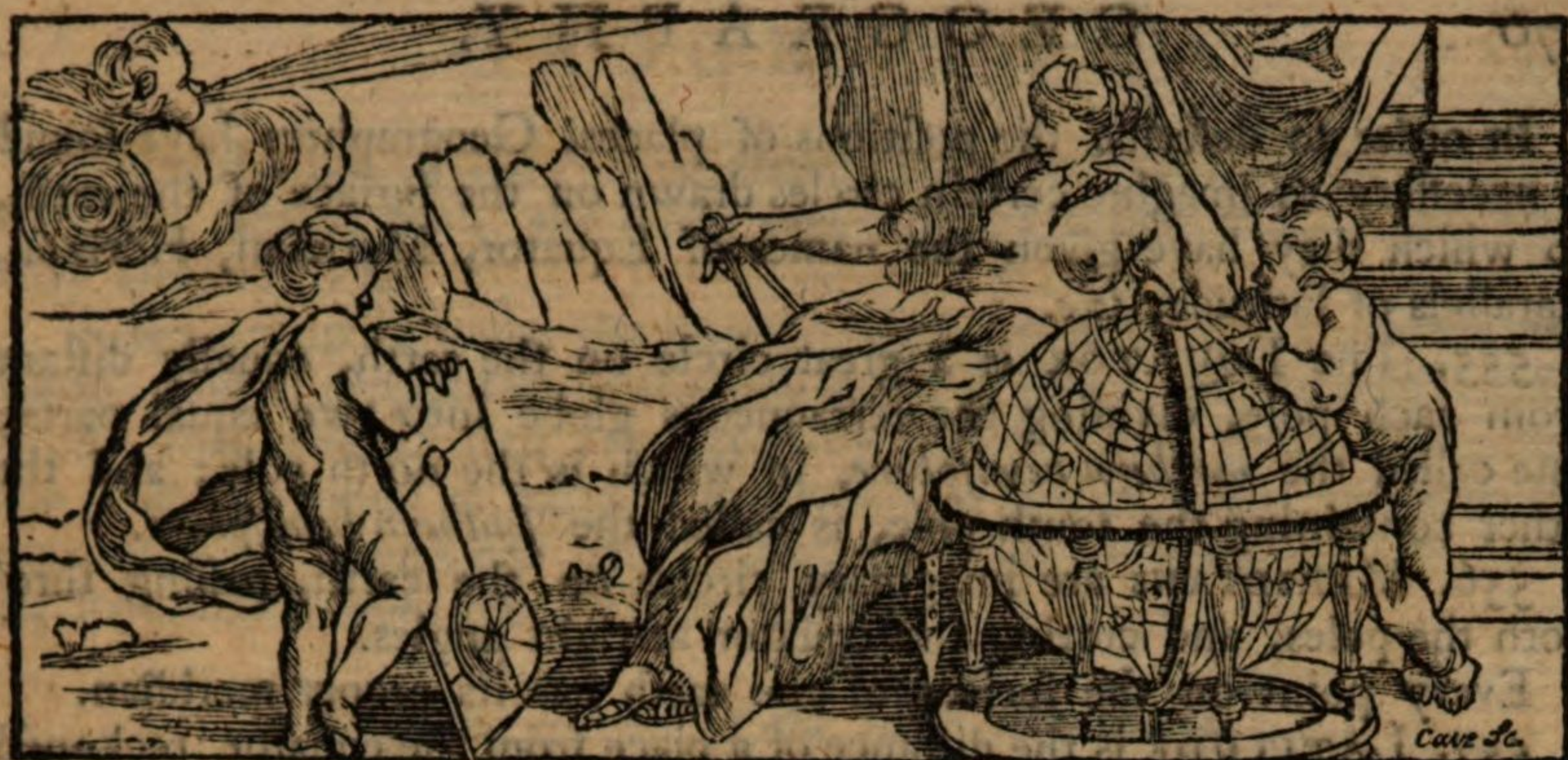
Sin. $\frac{1}{2}$ diff. $= 34^\circ 30\frac{1}{2}' \quad 9,75322$

Sum of four Logs $19,88905$

$\frac{1}{2}$ sum gives $61^\circ 39' \quad 9,94452$

The sup. of its double is $56^\circ 42' = BC$.

THE



THE
ELEMENTS
OF
NAVIGATION.

BOOK V.
OF GEOGRAPHY.

SECTION I.
Definitions and Principles.

552. **G**EOGRAPHY is the art of describing the figure, magnitude, and positions of the several parts of the surface of the earth.

553. The EARTH is a spherical or globular figure *; and is usually called the terraqueous globe.

554. There are two points on the surface of the terraqueous globe, called the POLES OF THE EARTH, which are diametrically opposite to one another; one is called the *north pole*, and the other, the *south pole*.

* For in ships at sea, the first parts of them that become visible are the upper sails; and as they approach nearer, the lower sails appear; and so on, until they shew their hulls.

Also ships, in sailing from high capes or head lands, lose sight of those eminences gradually from the lower parts, until the top vanishes.

Now as these appearances are the objects of our senses in all parts of the earth,

Therefore the surface of the earth must be convex.

And this convexity is, at sea, observed to be every where uniform.

But a body, whose surface is every where uniformly convex, is a globe.

Therefore the figure of the earth is globular.

In order to describe the positions of places, Geographers have found it necessary to imagine certain circles drawn on the surface of the earth, to which they have given the names of Equator, Meridian, Horizon, Parallels of latitude, &c.

555. The EQUATOR is a great circle on the earth, equally distant from each pole, dividing the terraqueous globe into two equal parts; one called the *northern hemisphere*, in which is the north-pole; and the other containing the south pole, is called the *southern hemisphere*.

556. MERIDIANS are imaginary circles on the earth, passing thro' both the poles, and cutting the equator at right angles.

Every point on the surface of the earth has its proper meridian.

557. LATITUDE is the distance of a place from the equator, reckoned in degrees and parts of degrees on a meridian.

On the north side of the equator it is north latitude; and on the south side it is south latitude.

As latitude begins at the equator, where it is nothing; so it ends at the poles, where the latitude is greatest, or 90 degrees.

558. PARALLELS OF LATITUDE are circles parallel to the equator.

Every place on the earth has its parallel of latitude.

DIFFERENCE OF LATITUDE is an arc of a meridian, or the least distance of the parallels of latitude of two places; shewing how far one of them is to the northward, or southward of the other.

The difference of latitude can never exceed 180 degrees.

559. In north latitudes, if about the middle of the months of March and September, a person looks towards the sun at noon, the south is before him, the north behind; the west on the right hand, and the east on the left: And in south latitudes, if the face is turned towards the sun, at the same times, the north is before, the south behind, the east to the right, and the west on the left.

In latitudes greater than $23\frac{1}{2}$ degrees, these positions found at noon, will hold good on any day of the year.

560. LONGITUDE of any place on the earth is expressed by an arc of the Equator, shewing the east or west distance of the meridian of that place from some fixed meridian where longitude is reckoned to begin.

561. DIFFERENCE OF LONGITUDE is an arc of the equator intercepted between the meridians of two places, shewing how far one of them is to the eastward, or westward of the other.

As longitude begins at the meridian of some place, and is counted from thence both eastward and westward, till they meet at the same meridian on the opposite point; therefore the difference of longitude can never exceed 180 degrees.

562. When two places have latitudes both north, or both south; or have longitudes both east, or both west; they are said to be of the same, or of like name: But when one has north latitude, and the other south, or if one has east longitude, and the other west, then they are said to have contrary, or different, or unlike names.

563. The HORIZON is that apparent circle which limits, or bounds the view of a spectator on the sea, or on an extended plain; the eye of the spectator being always supposed in the centre of his horizon.

When

When the sun or stars come above the eastern part of the horizon, they are said to rise; and when they descend below the western part, they are said to set.

When a ship is under the equator, both the poles appear in the horizon; and in proportion as she sails towards either, or increases her latitude, that pole is seen proportionally higher above the horizon, and the other disappears as much: But when a ship is sailing towards the equator, or decreases her latitude, she depresses the elevated pole; that is, its distance from the horizon decreases.

Of the division of the earth into Zones.

564. A ZONE is a broad space on the earth, included between two parallels of latitude.

There are five zones; namely, one *Torrid*, two *Frigid*, and two *Temperate*: These names arise from the quality of the heat and cold to which their situations are liable.

565. The TORRID ZONE is that portion of the earth, over every part of which the sun is perpendicular at one time of the year or other.

This zone is about 47 degrees in breadth, extending to about $23\frac{1}{2}$ degrees on each side of the equator; the parallel of latitude terminating the limits in the northern hemisphere is called the *Tropic of Cancer*; and in the southern hemisphere, the limiting parallel is called the *Tropic of Capricorn*.

566. The FRIGID ZONES are those regions about the poles where the sun does not rise for some days, nor set for some days of the year.

These zones extend round the poles to the distance of about $23\frac{1}{2}$ degrees: That in the northern hemisphere is called the north frigid zone, and is bounded by a parallel of latitude called the *Arctic polar circle*; and the other in the southern hemisphere, the south frigid zone, the parallel of latitude bounding it being called the *Antarctic polar circle*.

567. The TEMPERATE ZONES are those spaces between the Torrid and the Frigid zones.

Of the division of the earth by Climates.

568. A CLIMATE, in a geographical sense, is that space of the earth contained between two parallels of latitude, where the difference between the longest day in each parallel is half an hour.

These climates are narrower the farther they are from the equator; therefore, supposing the equator the beginning of the first climate, the polar circle will be the end of the 24th climate; for afterwards the longest day increases not by half hours, but by days and months.

S E C T I O N II.

Of the natural division of the Earth.

569. By the natural division of the earth is meant the parts on its surface formed by nature; such as *Continents, Oceans, Islands, Seas, Rivers, Mountains, &c.*

The surface of the earth is naturally divided into Land and Water.

Land is divided into	{	1. Continents.	4. Isthmus's.
		2. Islands.	5. Promontories.
		3. Peninsulas.	6. Mountains.

Water is divided into	{	1. Oceans.	4. Straits.
		2. Seas.	5. Lakes.
		3. Gulfs.	6. Rivers.

570. A **CONTINENT**, or, as it is frequently called, the *Terra Firma*, or *main land*, is a very large tract, comprehending several contiguous Countries, Kingdoms and States.

571. An **OCEAN** is a vast collection of salt-water, separating the continents from one another, and washing their borders or shores.

572. An **ISLAND** is a part of dry land surrounded with water.

573. A **SEA** is a branch of the Ocean, flowing between some parts of the continent, or separating an Island from the Continent.

574. A **PENINSULA** is a part of dry land encompassed by water, except a narrow neck which joins it to some other land.

575. An **ISTHMUS** is the neck joining the peninsula to the adjacent land, and forms the passage between them.

576. A **MOUNTAIN** is a part of the land more elevated than the adjacent country, whereby it is seen at a greater distance than the neighbouring lower lands.

577. A **PROMONTORY** is a mountain stretching itself into the sea; the extremity whereof is called a *Cape*, or *Head-land*.

578. A **HILL** is a small kind of mountain: A *Cliff* is a steep shore, hill, or mountain: And *Rocks* are great stones rising like hills above the dry land, or above the bottom of the sea.

579. A **GULF** or **BAY** is a part of the Ocean or Sea contained between two shores; and is every where environed with land except its entrance, where it communicates with other Bays, Seas or Oceans.

580. A **STRAIT** is a narrow passage, by which there is a communication between a Gulf and its neighbouring sea, or joining one part of the sea or ocean with another.

581. A **LAKE** is a collection of Waters contained in some hollow or cavity in an inland place, of a large extent, and every where surrounded with land; having no visible communication with the Ocean.

582. **RIVERS** are streams of Water flowing chiefly from the Mountains, and running in long narrow channels or cavities thro' the land till they either fall into the sea, or into other rivers, which at last disembogue or run into the sea.

583. There are generally reckoned four Continents, namely, EUROPE, ASIA, AFRICA, and AMERICA.

To these may be added two others, one called the *Terra artica*, or northern continent, and the other the *Terra antartica*, or southern continent.

The continent of *America* is usually divided into two parts, called *north* and *south America*.

The *Terra artica*, with *Europe* and *Asia*, lie all within the northern hemisphere; and also parts of *Africa* and *America*: The other parts of these two continents, together with the *Terra antartica*, lie in the southern hemisphere.

584. There are five Oceans, namely, the NORTHERN, the ATLANTIC, the PACIFIC, the INDIAN and the SOUTHERN.

The *Atlantic ocean* is usually divided into two parts, one called the *north Atlantic ocean*, and the other the *south Atlantic*, or *Ethiopic ocean*.

The *Northern ocean* stretches to the northward of *Europe*, *Asia* and *America*, towards the north pole.

The *Atlantic ocean* lies between the continents of *Europe* and *Africa* on the east, and *America* on the west.

That part of the north Atlantic ocean lying between *Europe* and *America* is frequently called the *Western ocean*.

The *Pacific ocean*, or, as it is sometimes called, the *South Sea*, is bounded by the western and north west shores of *America*, and by the eastern and north east shores of *Asia*.

The *Indian ocean* washes the shores of the eastern coasts of *Africa*, and the south of *Asia*; and is bounded on the east by the Indian islands and the southern continent.

The *Southern ocean* extends to the southward of *Africa* and *America* toward the south pole.

The northern and southern continents not being sufficiently known to Geographers; all that need be said of them, is, that the *Terra Artica*, or land to the northward of *Hudson's bay* and *Greenland*, is too cold for the residence of mankind; and that part which is known of the *Terra Antartica*, namely, *New Guinea*, *New Holland*, &c. appears to be very barren, and the natives very little superior to brutes.

S E C T I O N III.

Of the Political division of the Earth.

585. By the political division of the earth, is meant the different Countries, Empires, Kingdoms, States, and other denominations established by men, either by the ambition of tyrants, or for the sake of good government.

O F E U R O P E.

Europe is bounded on the north by the northern or frozen ocean; on the east by Asia; on the south by the Mediterranean sea, separating Europe from Africa; and by the north Atlantic or western ocean on the west: It lies between the latitudes of 36 and 72 degrees of north latitude; and between the longitudes of 10 degrees west, and 65 degrees east from London; is about 3000 miles long, reckoning from the N. E. to the S. W. and about 2500 miles broad.

586. The countries, their position with regard to the middle parts of Europe, the chief cities, principal rivers with their courses, and the most noted mountains, and what quarter of the country they are in, are exhibited in the following table; where E stands for empire, K for kingdom, R for republic, Nd. for northward, &c.

Countries.	Position.	Chief Cities.	Rivers.	Course.	Mountains.
E. Turkey	S. E.	Constantinople	Danube	E.	Argemum Nd.
K. Poland	Mid.	Warsaw	Vistula	N. N. W.	Carpathian Sd.
E. Muscovy	N. E.	{ Moscow { Petersburg	Wolga Neiper	E. to S. S.	Boglowy Sd. Riphean Nd.
K. Sweden	N.	Stockholm	Dalecarlia	E.	Dofrine Wd.
K. Norway	N. N. W.	Bergen	Glama	S.	Dofrine Ed.
K. Denmark	N. W.	Copenhagen			
K. Hungary	Mid.	Presburg	Danube	S. E.	Carpathian Nd.
E. Germany	Mid.	Vienna	Danube	E.	Alps Sd.
Italy	S.	Rome	{ Po { Tyber	E. S.	Alps Nd. Apennine Mid.
R. Switzerland	Mid.	Bern	Rhine	W.	Alps Sd.
Netherlands	W.	Brussels	Maese	N.	
R. Dutchland	W.	Amsterdam	Rhine	N. N. W.	
K. France	W.	Paris	{ Loire { Rhone	N. to W. S.	Pyrenees S.W. Alps Ed.
K. Spain	S.	Madrid	Tagus	W.	Pyrenees N. E.
K. Portugal	S. W.	Lisbon	Tagus	W.	C. Rocca W.
K. England	W.	London	Thames	E.	Malvern N.W.
K. Scotland	W.	Edinburg	Forth	E.	Grampian Nd.
K. Ireland	W.	Dublin	Shannon	S. W.	Knockpatric W.

There are in Europe four Kingdoms beside those enumerated above; but they are contained in the forenamed Countries.

The Kingdom of Prussia, which is part of Poland; the King's residence is at Berlin a city in Germany.

The

The Kingdom of Bohemia, a part of Germany; the ch. city is Prague.

The Kingdom of Sardinia, an Italian island; the king resides at Turin a city in Italy.

The Kingdom of the Sicilies, appending to Italy; the king resides at Naples a city in Italy.

In some of the forenamed countries, are several dominions, independent one of the other; particularly in Germany and Italy.

The principal states in Germany are the following 12: Where D stands for dutchy, El. for electorate, P for principality.

States	D. Auftria	K. Bohemia	El. Bavaria	El. Brandenburg
Ch. cities	Vienna	Prague	Munich	Berlin
States	El. Saxony	El. Hannover	El. Palatine	El. Mentz
Ch. cities	Dresden	Hannover	Manheim	Mentz
States	El. Triers	El. Cologne	P. Hesse Cassel	D. Wurtemberg
Ch. cities	Triers	Cologne	Cassel	Stutgard

The principal states in Italy are the following 12.

States	D. Savoy	P. Piedmont	D. Milanese	D. Parmesan
Ch. cities	Chambery	Turin	Milan	Parma
States	D. Modene	D. Mantuan	R. Venice	R. Genoa
Ch. cities	Modena	Mantua	Venice	Genoa
States	D. Tuscany	Patriarchate	R. Lucca	K. Naples
Ch. cities	Florence	Rome	Lucca	Naples

The principal Seas, Gulfs and Bays in Europe, are

587. The *Mediterranean Sea*, having Europe on the N. and Africa on the S.

The *Adriatic Sea*, between Italy and Turkey.

The *Euxine or Black Sea* in Turkey, between Europe and Asia.

The *White Sea* in the N. N. W. parts of Muscovy.

The *Baltic Sea* between Sweden, Denmark and Poland.

The *German Ocean*, or Sea, between Germany and Britain.

The *English Channel* between England and France.

The *Bay of Biscay* formed between France and Spain.

The *Gulf of Bothnia* in the N. E. parts of Sweden.

The *Gulf of Finland* between Sweden and Russia.

The *Gulf of Venice*, the N. W. end of the Adriatic sea.

The principal Islands in Europe, are

588. The *British Isles*, viz. Great Britain, Ireland, Orkneys and Western Isles.

The *Spanish Isles*; Majorca, Minorca, Ivica, in the Medit. sea.

Italian Isles; Sicily, Sardinia, Corfica, Lipari, in the Medit. sea.

Turkish Isles; Candia, Archipelago Isles, in the Medit. sea.

Swedish Isles; Gothland, Oeland, Alan, Rugen, in the Baltic sea.

Danish Isles; Zeland in the Baltic sea; and Iseland, Faro Isles, E. and W. Greenlands in the Northern ocean.

Azores Isles in the Atlantic ocean.

OF ASIA.

589. The continent of Asia is bounded on the north by the Northern or frozen ocean, on the east by the Pacific ocean, on the south by the Indian ocean, and by Africa and Europe on the west: It lies, including its Islands, between the latitudes of 10 degrees south, and 72 degrees north; and is between the longitudes of 25 and 148 degrees east of London: Its length, exclusive of the isles, being about 4800 miles, and breadth about 4300 miles.

590. The positions and names of the chief countries, cities, rivers and mountains, are contained in the following table.

Countries.	Position.	Chief Cities.	Rivers.	Course.	Mountains.
E. China	S. E.	{ Pekin Nankin Canton	Yellow R. Kiam Ta	S. to E. E. S. E.	Ottorocoran Nd Damafian Wd.
K. Korea	E.	Kingkitau	Yalu	S.	Shanalin
Chinese Tartary	E.	Chynian	Yamour	N. E. to E.	Fongwhanshan
Mongalia	Mid.	Kudak	Yellow R.	N. to W.	
K. Thibet	Mid.	Eskerdu	Yaru	E.	Kantes
Bukharia, or Usbecs	{ Mid.	Samarkand	Amu	N. W.	Belurlag
Karazm	Mid.	Urjenz	Amu	S. W.	Irder
Kalmucks	Mid.		Tekis		Tubratubusluk
E. Siberia	N.	{ Tobolski Astracan	Oby Jeniska	N. N. N. W.	Stolp
E. Turkey	W.	Smyrna	Euphrates	S. E.	Taurus
K. Syria	W.	Aleppo	Euphrates	S.	Lebanon
Arabia	S. W.	Medina	Euphrates	S. E.	Gabel el ared
E. Persia	S.	Isfahan	{ Oxus Araxes	W. S. W.	Caucasus Taurus
India	{ S.	Agra	Indus	S. W.	Caucasus
W. the Ganges		Delli	Ganges	S. W.	Balagate
India	{ S.	Ava	Domea	S.	{ Damascene
East the Ganges		Pegu	Mecon	S.	
		Siam	Menan	S.	
		Cambodia	Ava	S.	

Some of these countries contain several others.

Asiatic Turkey contains

Countries	Georgia N.	Turcomania E. or Armenia	Curdistan E. or Assyria	Diarbec E.
Ch. Cities	Teffis	Erzerum	Betlis	Moufol
Countries	Eyraca S. E.	Arabia desert S.	Natolia W.	Syria W.
Ch. Cities	Bagdat		Smyrna	Aleppo

India

India west the Ganges contains

Northern Parts	Countries	Indoſtan	N.	Cambaya	S. W.	Bengala S. E.
	Ch. Cities	De'li		or Guzarat Surat		Patna
Malabar Coast	Countries	Decan		Binnagar	W.	
	Ch. Cities	or Viſapour Goa		or Carnate Calcut and Cochin		
Coromandel Coast	Countries	Binnagar, or Carnate, E. ſide		K. Golconda		K. Orixa
	Ch. Cities	Madras		Golconda		Orixa

India eaſt the Ganges contains

Countries	K. Ava	N. W.	K. Pegu	W.	K. Siam Sd.	K. Malacca S.
Ch. Cities	Ava		Pegu		Siam	Malacca
Countries	K. Cambodia S.		K. Cochin China E.		K. Laos N.	K. Tonquin N. E.
Ch. Cities	Cambodia		Thoanoa		Lanchan	Keccio

591. *The principal Seas, Gulfs and Bays in Aſia, are*

Caspian Sea, quite ſurrounded by Siberia on the north, Korazm eaſt, by Perſia on the ſouth, and by Georgia on the weſt.

Korean Sea, between Korea and the Iſlands of Japan.

Yellow Sea, between China and the Japan iſles.

Gulf of Cochin China, on the borders of Tonquin and Cochin China.

Bay of Siam, formed by the countries of Siam and Malacca.

Bay of Bengal, between India eaſt, and India weſt the Ganges.

Gulf of Perſia, having Perſia on the N. E. and Arabia on the S. W.

592. *The principal Iſlands belonging to Aſia, are*

Ladrone, or Marian Iſles, whoſe chief Iſland is Guam.

<i>Japan Iſles</i>	Ch. Iſles	Japan	Bongo	Tonfa
	Ch. Cities	Jeddo	Bongo	Tonfa
<i>Philippines</i>	Ch. Iſles	Luconia	Mindanao	Samar
	Ch. Cities	Manila	Mindanao	
<i>Chineſe Iſles</i>	Ch. Iſles	Formoſa	Ainan	Makao
	Ch. Cities	Taywanfu	Tan	Makau
<i>Moluccos</i>	Ch. Iſles	Celebes	Gilolo	Ceram
	Ch. Cities	Macaffer	Gilolo	Ambay
<i>Sunda Iſles</i>	Ch. Iſles	Borneo	Sumatra	Java
	Ch. Cities	Banjar	Achin	Batavia

The Andaman Iſles to the weſt of Siam.

Nicobar Iſles weſt of Malacca.

Maldiva Iſlands to the S. W. of Biſnagar.

The Iſland of Ceylon S. E. of Biſnagar; the chief city is Candy, or Candy Uta.

O F A F R I C A.

593. This large continent is a peninsula joined to Asia by the Isthmus of Suez. On the N. E. it is separated from Asia by the Red sea; it has the Indian ocean on the east, the Southern on the south, the Atlantic on the west, and the Mediterranean sea on the north, which separates it from Europe. It is situated between the latitudes of 37 degrees N. and 35 degrees S.; and between the longitudes of 18 degrees W. and 50 degrees E. from London; is about 4300 miles long, and 4200 miles broad.

594. The positions and names of the chief countries, cities, rivers and mountains, are contained in the following table.

Countries.	Position	Chief Cities.	Rivers.	Course.	Mountains.
E. Morocco	N. W.	Fez	Mulvia	N.	Atlas
K. Algiers	N.	Algiers	Saffran	N.	Atlas
K. Tunis	N.	Tunis	Megarada	N.	Atlas
K. Tripoli	N.	Tripoli	Salines	N. E.	Atlas
K. Barca	N.	Docra			Meies
K. Egypt	N. E.	Cairo	Nile	N.	Gianadel
E. Abyssinia } or Ethiopia }	E.	Ambamarjam	Nile	N.	
Ajan	E.	Adea	Madadox	S.	
Zanguebar	E.	Melinda	Cuama	E. S. E.	
Sofala	S. E.	Sofala	Amara	E.	Amara
Terra de Natal	S. E.	Natal	St. Esprit	E.	Amara
Cafraria	S.	Cape Town	St. Christopher	E.	Table
Mataman	S. S. W.		Angri	W.	Sunda
K. Benguela	S. S. W.	Benguela	Negros	W.	Sunda
K. Angola	S. W.	Loando	Coanza	W.	Sunda
K. Congo	S. W.	St. Salvador	Zaara	S. W.	Sunda
K. Loango	S. W.	Loango	Zette	S. W.	St. Esprit
Biafara	S. W.	Biafara	Camerones	S. W.	St. Esprit
K. Benin	S. W.	Benin	Formosa	S. W.	
Guinea	S. W.	Cape Coast	Volta	S.	Sierra Leona
Mandinga	W.	James Fort	Gambia	W.	C. Verd
Sanhaga	W.	Sanhaga	Senagal	N. W.	
Biledulgerid	Mid. N.	Dara	Dara	S.	Atlas
Zara	Mid.	Zuenzega	Nubia	E.	
Nubia	Mid.	Nubia	Nubia	E.	
Negroland	Mid.	Tombute	Niger	W.	
Ethiopia inter.	Mid.	Chaxumo	Niger	W.	Luna
Monomugi	Mid. S.	Merango	Cuama	E. S. E.	Luna
E. Monomotapa	Mid. S.	Mogar	Amara	S. E.	Amara

Great part of the coasts of Africa are subject to the European nations. Thus the Kingdoms of Algiers, Tunis, Tripoli, Barca and Egypt, are either subject to the Ottoman or Turkish Empire, or acknowledge themselves under its protection.

Abyssinia

Abyssinia is governed by its own Emperor.

Ajan or Anian is peopled by a few wild Arabs.

In Zanguebar and Sofala, the Portuguese have many black princes tributary to them.

Caffraria, or the country of the Hottentots, belongs to the Dutch.

The sea coasts of Guinea are usually distinguished by the names of the *Slave coast*, *Gold coast*, *Ivory coast*, *Grain coast*, and *Sierra Leone*.

The English, Dutch, French, Portuguese and others, have several settlements along these coasts, and even many miles up the country, particularly the English on the river Gambia, and the French on the river Senaga, or Senegal.

In the general table, the countries are taken in a very large sense; for many of them contain a great number of states independent one of the other, the particulars whereof are not known to Geographers.

595. *The principal Seas, Gulf and Bays in Africa, are*

The *Red Sea*, between Africa and Asia: It washes the coast of Arabia on the Asiatic side, and the coasts of Egypt and Abyssinia on the African side.

Mosambique Sea, between Africa and the island of Madagascar eastward, *Saldanna Bay* in Caffraria, on the Ethiopic ocean.

Bight of Benin on the coast of Guinea, in the Ethiopic ocean.

596. *The principal African Islands are*

	Chief Isle.	Chief Town.	Situation.
<i>Madeira isles</i>	Maderia	Funchal	N. Atlantic ocean
<i>Canary isles</i>	Canaria	Palma	N. Atlantic ocean
<i>C. Verd isles</i>	St. Jago	St. Jago	N. Atlantic ocean
<i>Ethiopian isles</i>	St. Helena		Ethiopic ocean
<i>Komora isles</i>	Johanna	Demani	Indian ocean
<i>Sokotora isles</i>	Zocotora	Calansia	Indian ocean
<i>Almirante isles</i>	But little	known.	Indian ocean

The island of *Madagascar*, one of the largest in the world, lies in the Indian ocean: It is divided into a multitude of little states; some of them formed by the European privateers, and their successors descended from mixing with the natives.

The islands of *Bourbon* and *Mauritius* lie in the Indian ocean, to the east of Madagascar: These belong to the French.

The *Madeiras* and *Cape de Verd isles* belong to the Portuguese.

The *Canary isles* to Spain; *St. Helena* to England.

O F A M E R I C A.

597. This vast continent, called by some the new world, having been discovered by the Europeans since the year 1492, is usually divided into two parts, one called North, and the other South America; being joined to one another by the Isthmus of Darien.

North America lies between the latitudes of 10 degrees and 80 degrees north; and chiefly between the longitudes of 50 degrees and 130 degrees west of London; is about 4200 miles from north to south, and about 4800 from east to west. It is bounded on the east by the north Atlantic ocean, by the Gulf of Mexico on the south; on the west by the Pacific ocean, and by the Northern continent and ocean to the northward.

South America is bounded on the east by the south Atlantic ocean, by the Southern ocean to the south, by the Pacific ocean on the west, and on the north by the Caribbean sea: It lies between the latitudes of 12 degrees north and 58 degrees south; and between the longitudes of 45 degrees and 83 degrees west from London; is about 4200 miles long, and about 2200 miles in breadth.

598. The positions and names of the chief countries, cities, rivers and mountains, in north America, are in the following table.

Countries.	Position	Chief Cities.	Rivers.	Course.	Mountains.
California	W.	St. Juan			
New Mexico	S.	Santa Fe	N. River	S. S. E.	
Old Mexico	S. W.	Mexico	Panuco	E.	
Louisiana	S.	Fort Louis	Mississipi	S.	
Florida	S.	St. Augustin	St. John	N. to E.	Apalachian
Georgia	S. S. E.	Savannah	Alatamaha	E. S. E.	Apalachian
Carolina	S. E.	Charles Town	Ashly	S. E.	Apalachian
Virginia	E.	James Town	Powtomack	S. E.	Apalachian
Maryland	E.	Annapolis	Powtomack	S. E.	Apalachian
Pensilvania	E.	Philadelphia	Delawar	S.	Apalachian
Jerseys	E.	New York	Albany	S.	
New England	E.	Boston	Connecticut	S.	
Nova Scotia	N. E.	Hallifax	St. John	S. S. E.	Ladies
Canada	Mid.	Quebec	St. Lawrence	N. E.	
New Britain	N. N. E.	Port Rupert	Rupert	W.	
New Wales	N.	Port Nelson	Nelson	W.	

California, Old Mexico, New Mexico and Florida, belong to Spain.

Louisiana and Canada are possessed by the French.

All the other countries are in the hands of the English.

In south America, the position and names of the chief countries, cities, rivers and mountains, are as follows.

Countries.	Position.	Chief Cities.	Rivers.	Course.	Mountains
Terra firma	N.	Panama	Oronoque	N. E.	
Peru	W.	Lima	Chuquimayo	W. N. W.	Andes
Chili	S. W.	St. Jago	Valpariso	W.	Andes
Patagonia	S.		Desaguadero	S.	Andes
La Plata	S. E.	Buenos Ayres	La Plata	S.	Andes
Paraguay	Mid.	Assumption	Paragua	S.	
Brasil	E.	St. Salvador	Rio Real	N. E.	
Amazonia	Mid.		Amazons	E.	
Guiana	N. E.	Surinam	Esquebe	N. N. E.	

Terra firma, Peru, Chili, La Plata and Paraguay, are in the possession of the Spaniards.

Brasil belongs to the Portuguese.

Patagonia, Amazonia and Guiana, are possessed by the native Indians, except some parts of the coasts of Guiana in the hands of the Dutch and French.

599. *The principal Seas, Gulfs and Bays, in America.*

The *Caribbean Sea*, bounded by Terra firma on the south, and a range of islands on the north and east.

Gulf of Mexico, formed by Old Mexico, Louisiana and Florida.

Bay of Campeachy, part of the Gulf of Mexico, on the Mexican coast.

Bay of Honduras, part of the Caribbean sea, next to Mexico.

Bay of Panama, in the Pacific ocean, next the Isthmus of Darien.

Gulf of California, in the Pacific ocean, having California on the west.

Bay of Fundy, in Nova Scotia, north Atlantic ocean.

Gulf of St. Lawrence, in the north Atlantic ocean, bounded by Nova Scotia, New Britain, and some islands eastward and south eastward.

Hudson's Bay, between New Britain E. and New Wales W.

600. *The chief American Islands in the Atlantic ocean.*

Newfoundland, and *Cape Breton*, east of the Gulf of St. Lawrence.

Bermudas, or *summer islands*, east of Carolina.

Bahama isles, south east of Florida.

Great Antilles	{	Cuba	Ch. town Havanna	} lying E. of the Mexican gulf, and N. of the Carib. sea.
		Hispaniola	Ch. town St. Domingo	
		Jamaica	Ch. town Kingston	

Caribbe isles, bounding the Caribbean sea on the E. and N. E.

Lesser Antilles, on the N. N. E. of Terra firma, in the Caribbe sea.

Terra del fuego, on the south of Patagonia, in the southern ocean.

Gallipago isles, lying N. W. of Peru in the Pacific ocean.

Solomons isles, south of the Equator in the Pacific ocean.

SECTION

S E C T I O N IV.

Of Winds.

601. A FLUID is a body whose particles readily give way to any impressed force; and by this readiness of yielding the particles are easily put into motion.

Thus, not only liquids, but steams or vapours, smoke or fumes, and others of a like kind, are reckoned as fluids.

From all parts of the earth vapours and fumes are constantly arising to some distance from its surface.

This is known by observation; and is chiefly caused by the heat of the sun, and sometimes from subterraneous fires arising from the accidental mixing of some bodies.

602. AIR is a fine invisible fluid surrounding the globe of the earth, and extended to some miles above its surface.

The ATMOSPHERE is that collection of air, and the bodies contained in it, which circumscribes the earth.

603. From a multitude of experiments air is found to be both heavy and springy.

By its weight, it is capable of supporting other bodies, such as vapours and fumes, in the same manner as wood is supported by water.

By its springiness or elasticity, a quantity of air is capable of being expanded, or spreading itself so as to fill a larger space*; and of being compressed, or confined in a smaller compass†.

604. Air is compressed or condensed by cold, and expanded or rarified by heat.

This is evident from a multitude of experiments.

An alteration being made by heat or cold in any part of the Atmosphere, its neighbouring parts will be put into motion by the endeavour which the air always makes to restore itself to its former state.

For experiments shew, that condensed or rarified air will return to its natural state, when the cause, whatever it be, of that condensation or rarefaction is removed.

605. Wind is a stream or current of air which may be felt; and usually blows from one part of the Horizon to its opposite part.

606. The *horizon*, besides being divided into 360 degrees like all other circles, is by mariners supposed to be divided into four *quadrants*, called the north east, north west, south east and south west quarters; each of these quarters they divide into eight equal parts called points, and each point into four equal parts called quarter points.

So that the horizon is divided into 32 points, which are called *rhumbs* or *winds*; to each wind is assigned a name, which shews from what point of the horizon the wind blows.

The points of North, South, East and West, are called *cardinal points*; and are at the distance of 90 degrees, or 8 points from one another.

* Near 14000 times. *Wallis's Hydrosf.* p. 13.

† Into 40 part. *Phil. Transf.* N° 181.

607. Winds are either constant or variable, general or particular.

Constant winds are such as blow the same way, at least, for several hours or days; and *variable winds* are such as frequently shift within an hour or day.

A *general wind* is that which blows the same way, over a large tract of the earth, almost the whole year.

A *particular wind* is what blows, in any place, sometimes one way, and sometimes another indifferently.

If the wind blows gently it is called a breeze; if it blows harder it is called a gale, or a stiff gale; and if it blows very hard it is called a storm *.

608. The following observations on the wind have been made by skilful seamen; and particularly by the great Dr. Halley.

1st. Between the limits of 60 degrees, namely, from 30° of north latitude to 30° of south latitude, there is a constant east wind throughout the year, blowing on the Atlantic and Pacific oceans; and this is called the *trade wind*.

FOR as the sun, in moving from east to west, heats the air more immediately under him, and thereby expands it; the air to the eastward is constantly rushing towards the west to restore the equilibrium, or natural state of the Atmosphere, and this occasions a perpetual east wind in those limits.

2d. The trade winds near their northern limits blow between the north and east; and near the southern limits they blow between the south and east.

FOR as the air is expanded by the heat of the sun near the Equator; therefore the air from the northward and southward will both tend towards the Equator to restore the equilibrium: Now these motions from the north and south, joined with the foregoing easterly motion, will produce the motions observed near the said limits between the north and east, and between the south and west.

3d. These general motions of the wind are disturbed on the continents and near their coasts.

FOR the nature of the soil may either cause the air to be heated or cooled; and hence will arise motions that may be contrary to the foregoing general ones.

4th. In some parts of the Indian ocean there are periodical winds which are called *MONSOONS*; that is, such as blow half the year one way, and the other half year the contrary way.

FOR air that is cool and dense, will force the warm and rarified air in a continual stream upwards, where it must spread itself to preserve the equilibrium: So that the upper course or current of the air shall be contrary to the under current; for the upper air must move from those parts where the greatest heat is; and so by a kind of circulation, the N. E. trade wind below will be attended with a S. W. above; and a S. E. below with a N. W. above: And this is confirmed by the experience of seamen, who, as soon as they get out of the trade winds, immediately find a wind blowing from the opposite quarter.

* The swiftness of the wind in a great storm is not more than 50 or 60 miles in an hour; and a common brisk gale is about 15 miles an hour.

5th.

5th. In the Atlantic ocean, near the coasts of Africa, at about 100 leagues from shore, between the latitudes of 28° and 10° north, seamen constantly meet with a fresh gale of wind blowing from the N. E.

6th. Those bound to the Caribbe islands, across the Atlantic ocean, find, as they approach the American side, that the said N. E. wind becomes easterly; or seldom blows more than a point from the east, either to the northward or southward.

These trade winds, on the American side, are extended to 30 , 31 , or even to 32° of N. latitude; which is about 4° farther than what they extend to on the African side: Also to the southward of the Equator, the trade winds extend 3 or 4 degrees farther towards the coast of Brasil on the American side, than they do near the Cape of Good Hope on the African side.

7th. Between the latitudes of 4° North and 4° South, the wind always blows between the south and east: On the African side the winds are nearest the south; and on the American side nearest the east. In these seas Dr. Halley observed, that when the wind was eastward, the weather was gloomy, dark and rainy, with hard gales of wind: But when the wind veered to the southward, the weather generally became serene, with gentle breezes next to a calm.

These winds are somewhat changed by the seasons of the year; for when the sun is far northward, the Brasil S. E. wind gets to the south, and the N. E. wind to the east; and when the sun is far south, the S. E. wind gets to the east, and the N. E. winds on this side of the Equator veer more to the north.

8th. Along the coast of Guinea, from Sierra Leone to the island of St. Thomas (under the Equator), which is above 500 leagues, the southerly and south west winds blow perpetually: For the S. E. trade wind having passed the Equator, and approaching the Guinea coast within 80 or 100 leagues, inclines towards the shore, and becomes south, then S. E. and by degrees as it comes near the land it veers about to south, S. S. W. and in with the land it is S. W. and sometimes W. S. W. This tract is troubled with frequent calms, violent sudden gusts of wind called Tornados, blowing from all points of the horizon.

The reason of the wind setting in west on the coast of Guinea, is in all probability owing to the nature of the coast, which being greatly heated by the sun, rarifies the air exceedingly, and consequently the cool air from off the sea will keep rushing in to restore the equilibrium.

9th. Between the 4th and 10th degrees of north latitude, and between the longitudes of Cape Verd, and the eastermost of the Cape Verd isles, there is a tract of sea which seems to be condemned to perpetual calms, attended with terrible thunder and lightnings, and such frequent rains, that this part of the sea is called the *rains*. Ships in sailing these 6 degrees have been sometimes detained whole months, as it is reported.

The cause of this seems to be, that the westerly winds setting in on this coast, and meeting the general easterly wind in this tract, balance each other, and so cause the calms; and the vapours carried thither by each wind meeting and condensing, occasion the almost constant rains.

The

The last three observations shew the reason of two things which Mariners experience in sailing from Europe to India, and in the Guinea trade.

And first. The difficulty which ships in going to the southward, especially in the months of July and August, find in passing between the coast of Guinea and Brasil, notwithstanding the width of this sea is more than 500 leagues: This happens because the S. E. winds at that time of the year commonly extend some degrees beyond the ordinary limits of 4° N. latitude; and besides coming so much southerly, as to be sometimes south, sometimes a point or two to the west; it then only remains to ply to windward: And if on the one side they steer W. S. W. they get a wind more and more easterly; but then there is danger of falling in with the Brasilian coast or shoals; and if they steer E. S. E. they fall into the neighbourhood of the coast of Guinea, from whence they cannot depart without running easterly as far as the island of St. Thomas; and this is the constant practice of all the Guinea ships.

Secondly. All ships departing from Guinea for Europe, their direct course is northward; but on this course they cannot go, because the coast bending nearly east and west, the land is to the northward: Therefore as the winds on this coast are generally between the S. and W. S. W. they are obliged to steer S. S. E. or south, and with these courses they run off the shore; but in so doing they always find the winds more and more contrary: So that when near the shore they can lie south, at a greater distance they can make no better than S. E., and afterwards E. S. E.; with which courses they commonly fetch the island of St. Thomas and Cape Lopez, where finding the winds to the eastward of the south, they sail westerly with it till coming to the latitude of 4 degrees south, where they find the S. E. wind blowing perpetually.

On account of these general winds, all those that use the West India trade, even those bound to Virginia, reckon it their best course to get as soon as they can to the southward, that so they may be certain of a fair and fresh gale to run before it to the westward: And for the same reason those homewards bound from America endeavour to gain the latitude of 30 degrees, where they first find the winds begin to be variable; tho' the most ordinary winds in the north Atlantic ocean come from between the south and west.

10th. Between the southern latitudes of 10 and 30 degrees in the Indian ocean, the general trade wind about the S. E. by S. is found to blow all the year long in the same manner as in the like latitudes in the Ethiopic ocean: And during the six months from May to December, these winds reach to within 2 degrees of the Equator; but during the other six months from November to June, a N. W. wind blows in the tract lying between the 3d and 10th degrees of southern latitude, in the meridian of the north end of Madagascar; and between the 2d and 12th degree of south latitude, near the longitude of Sumatra and Java.

11th. In the tract between Sumatra and the African coast, and from 3 degrees of south latitude quite northward to the Asiatic coasts, including the Arabian sea and the Gulf of Bengal, the Monsoons blow from September to April on the N. E.; and from March to October on the S. W. In the former half year the wind is more steady and gentle, and the weather clearer than in the latter six months: And the wind is more strong and steady in the Arabian sea than in the Gulf of Bengal.

12th. Between the island of Madagascar and the coast of Africa, and thence northward as far as the Equator, there is a tract, wherein from April to October there is a constant fresh S. S. W. wind; which to the northward changes into the W. S. W. wind, blowing at that time in the Arabian sea.

13th. To the eastward of Sumatra and Malacca on the north of the Equator, and along the coasts of Cambodia and China, quite thro' the Philippines as far as Japan, the Monsoons blow northerly and southerly; the northern setting in about October or November, and the southern about May: The winds are not quite so certain as those in the Arabian seas.

14th. Between Sumatra and Java to the west, and New Guinea to the east, the same northerly and southerly winds are observed; but the first half year monsoon inclines to the N. W. and the latter to the S. E. These winds begin a month or six weeks after those in the Chinese seas set in, and are quite as variable.

15th. These contrary winds do not shift from one point to its opposite all at once; in some places the time of the change is attended with calms, in others by variable winds: And it often happens on the shores of Coromandel and China, towards the end of the monsoons, that there are most violent storms, greatly resembling the hurricanes in the West Indies; wherein the wind is so vastly strong, that hardly any thing can resist its force.

All navigation in the Indian ocean must necessarily be regulated by these winds; for if Mariners should delay their voyages till the contrary monsoon begins, they must either sail back, or go into harbour, and wait for the return of the trade wind.

S E C T I O N V.

Of the Tides.

609. A TIDE is that motion of the water in the Seas and Rivers, by which they are found regularly to rise and fall.

The general causes of the tides were discovered by Sir Isaac Newton, and are deduced from the following considerations.

610. Daily experience shews, that all bodies thrown upwards from the earth, fall down to its surface in perpendicular lines; and as lines perpendicular to the surface of a sphere tend towards the centre, therefore the lines, along which all heavy bodies fall, are directed towards the earth's centre.

As these bodies apparently fall by their weight or gravity; therefore the law by which they fall, is called the LAW OF GRAVITATION.

611. A piece of glass, amber, or sealing wax, and some other things, being rubbed against the palm of a hand, or against a woollen cloth, until it be warmed, will draw bits of paper, or other light substances towards it, when held sufficiently near those substances.

Also a Magnet or Loadstone being held near the filings of iron or steel, or other small pieces of these substances, will draw them to itself; and a piece of hammered iron or steel, that has been rubbed by a magnet, will have a like property of drawing iron or steel to itself.

And this property in some bodies of drawing others to themselves in the foresaid manner, is called ATTRACTION.

612. Now as bodies by their gravity fall towards the earth, it is not improper to say it attracts those bodies; and therefore in respect to the earth, the words gravitation and attraction may be used one for the other; as by them is meant no more than the power or law by which bodies tend towards its centre.

And it is likely that this is the cause why the parts of the earth adhere and keep close to one another.

613. The incomparable Sir Isaac Newton, by a sagacity peculiar to himself, discovered from many observations, that this law of gravitation or attraction was universally diffused throughout the world; and that the regular motions observed among the heavenly bodies were governed by this same principle; so that the earth and moon attracted each other, and both of them were attracted by the sun: Also that the force of attraction exerted by these bodies one on the other was less and less as the distance increased, in proportion to the squares of those distances; that is, the power of attraction at double the distance was four times less, at triple the distance, nine times less, at quadruple the distance, sixteen times less, and so on.

614. Now as the earth is attracted by the sun and moon, therefore all the parts of the earth will not gravitate towards its centre in the same manner as if those parts were not affected by such attractions: And it is very evident that, was the earth intirely free from such actions of the sun and moon, the oceans being equally attracted towards its centre, on all sides by the force of gravity, would continue in a perfect stagnation without ever Ebbing or Flowing: But since the case is

otherwise, the oceans must needs rise higher in those places where the sun and moon diminish their gravity, or where the sun and moon have the greatest attraction.

As the force of gravity must be diminished most in those parts of the earth to which the Moon is nearest, or in the ZENITH; that is, where she is vertical or perpendicularly over, and consequently where her attraction is most powerful; therefore the waters in such places will rise higher, and it will be *full sea* or *flood* in such places.

615. *The parts of the earth directly under the moon, and also those in their NADIR, viz. such places diametrically opposite to those where the moon is in the Zenith, will have the flood or high water at the same time.*

FOR either half the earth would gravitate equally towards the other half, were they free from all external attraction.

But by the action of the moon, the gravitation of one half-earth towards its centre is diminished, and of the other is increased.

Now in the half-earth next the moon, the parts in the zenith being most attracted, and thereby their gravitation towards the earth's centre diminished; therefore the waters in these parts must be higher than in any other part of this half-earth.

And in the half-earth farthest from the moon, the parts in the nadir being less attracted by the moon than the parts nearer to her, do therefore gravitate less towards the earth's centre, and consequently the waters in these parts must be higher than they are in any other part of this half-earth.

616. *Those parts of the earth where the moon appears in the horizon, or is 90 degrees distant from the Zenith and Nadir, will have the ebbs or lowest waters.*

FOR as the waters in the Zenith and Nadir rise at the same time, the waters in their neighbourhood will press towards those places to maintain the equilibrium; and to supply the places of these, others will move the same way, and so on to places 90° distant from the said Zenith and Nadir: Consequently in those places where the moon appears in the horizon, the waters will have more liberty to descend towards the centre; and therefore in those places they will be the lowest.

617. Hence it plainly follows, that the ocean, did it cover the surface of the earth, must put on a spheroidal, or egg-like figure; wherein the longest diameter passes thro' the place where the moon is vertical; and the shortest diameter will be where she is in the horizon. And as the moon apparently shifts her position from east to west in going round the earth every day, the longer diameter of the spheroid following her motion, will occasion the two floods and ebbs observable in about every 25 hours, which is the length of a lunar day; that is, the time spent between the moon's leaving the meridian of any place, and coming to it again; So that the time of high water any day is about an hour later than it was the preceding day. Thus suppose it is high water to day at 12 o'clock, it will be high water to-morrow about one in the afternoon.

618. *The time of high water is not precisely at the time of the moon's coming to the meridian, but about three hours after.*

FOR the moon acts with some force after she has past the meridian, and thereby adds to the libratory or waving motion which she has put the water into, whilst she was in the meridian; in the same manner as a small force applied to a ball already raised to some height, will raise it still higher.

619. *The Tides are greater than ordinary twice every month; that is, about the times of new and full moon: These are called SPRING TIDES.*

FOR at these times the actions of both the sun and moon concur, or draw in the same right line; and therefore the sea must be more elevated: In *conjunction*, or when the sun and moon are on the same side of the earth, they both conspire to raise the water in the Zenith, and consequently in the Nadir: And when the sun and moon are in *opposition*, that is when the earth is between them, whilst one makes high water in the Zenith and Nadir, the other does the same in the Nadir and Zenith.

620. *The tides are less than ordinary twice every month; that is about the times of first and last quarters of the moon: And these are called NEAP TIDES.*

BECAUSE in the quarters of the moon, the sun raises the water where the moon depresses it; and depresses where the moon raises the water; so that the tides are made only by the difference of their actions.

It must be observed that the spring tides happen not directly on the new and full moons, but rather a day or two after, when the attractions of the sun and moon have conspired together for a considerable time. In like manner the Neap tides happen a day or two after the quarters, when the moon's attraction has been lessened by the sun's for several days together.

621. *When the moon is in her PERIGÆUM, or nearest approach to the earth, the tides increase more than in the same circumstances at other times.*

FOR according to the laws of gravitation, the moon must attract most when she is nearest to the earth.

622. *The spring tides are greatest about the time of the EQUINOXES, that is about the middles of March and September, than at other times of the year; and the neap tides then are less.*

BECAUSE the longer diameter of the spheroid, or the two opposite floods, will at that time be in the earth's Equator; and consequently will describe a great circle of the earth; by whose diurnal rotation those floods will move swifter, describing a great circle in the same time they used to describe a lesser circle parallel to the equator, and consequently the waters being thrown more forcibly against the shores, they must rise higher.

623. All the things hitherto explained would exactly obtain, was the whole surface of the earth covered with sea: But since it is not so, and there being a multitude of islands, beside continents, lying in the way of the tide, which interrupt its course; therefore in many places near the shores, there arise a great variety of other appearances beside the foregoing ones, which require particular solutions, wherein the situation of the shores, straits, shoals and other things, must necessarily be considered. For instance;

624. As the sea * has no visible passage between Europe and Africa, let them be supposed one continent, extending from 72 degrees north to 34 degrees south, the middle between these two would be in latitude 19 degrees north, near Cape Blanco on the west coast of Africa: But it is impossible that the flood tide should set to the westward upon the west coast of Africa (for the general tide following the course of the moon, must set from east to west), because the continent for above 50 degrees both northward and southward bounds that sea on the east; and therefore if any regular tide, as proceeding from the motion of the sea, from east to west, should reach this place, it must either come from the north of Europe southward, or from the south of Africa northward, to the said latitude upon the west coast of Africa.

625. This opinion is further corroborated, or rather fully confirmed, by common experience, that the flood tide sets to the southward along the west coast of *Norway*, from the north cape to the *Naze*, or entrance of the *Baltic Sea*, and so proceeds to the southward along the east coast of *Great Britain*, and in its passage supplies all those ports with the tide one after another, the coast of *Scotland* having the tide first, because it proceeds from the northward to the southward; and thus on the days of the full or change it is high water at *Aberdeen* at 12 h. 45 m. but at *Tinmouth bar*, the same day, not till 3 h. From thence rolling to the southward it makes high water at the *Spurn* a little after 5 h. but not till 6 h. at *Hull*, by reason of the time required for its passage up the river; from thence passing over the *Wellbank* into *Yarmouth road*, it makes high water there a little after 8 h. but in the *Pier* not till 9 h. and it requires near an hour more to make high water at *Yarmouth town*; in the mean time setting away to the southward, it makes high water at *Harwich* at 10 h. 30 m. at the *Nore* at 12, at *Gravesend* 1 h. 30 m. and at *London* at 3 h. all in the same day: And although this would seem to contradict that hypothesis, of the natural motion of the tide being from east to west, yet as no tide can flow west from the main continent of *Norway* or *Holland*, or out of the *Baltic*, which is surrounded by the main continent except at its entrance, it is evident, that the tide we have been now tracing by its several stages from *Scotland* to *London*, is supplied by the tide whose original motion is from east to west; yet as water always inclines to the level, it will in its passage fall towards any other point of the compass, to fill up vacancies where it finds them, and yet not contradict, but rather confirm the first hypothesis.

626. While the tide or high water is thus gliding to the southward along the east coast of *England*, it also sets to the southward along the west coasts of *Scotland* and *Ireland*, a branch of it falls into St. George's channel, the flood running up north east, as may be naturally inferred from its being high water at *Waterford* above three hours before it is high water at *Dublin* or thereabout on that coast; and it is three quarters of an hour ebb at *Dublin* before it is high water at the *Isle of Man*, &c.

But not to proceed further in particulars than our own or the *British* channel, we find the tides set to the southward from the coast of *Ireland*, and in its passage a branch of it falls into the *British* channel between

* *Varenius's Geogr.* p. 813. Edit. 1734.

the *Lizard* and *Ushant*; its progress to the southward may be easily proved, by its being high water on the day of the full and change at *Cape Clear* after 4 h. and at *Ushant* about 6 h. and at the *Lizard* after 7 h. The *Lizard* and *Ushant* may properly be called the chaps of the *British* channel, between which the flood sets to the eastward along the coasts of *England* and *France*, till it comes to the *Goodwin* or *Galloper*, where it meets the tide beforementioned, which sets to the southward, along the coast of *England* to the *Thames*, where these two tides meeting, contribute very much towards sending a powerful tide up the *Thames* to *London*: And by the bye, when the natural course of the tide is interrupted by a sudden shift of the wind; and between this northern and southern side, driving one back, and the other in, has been known to occasion twice high water in 3 or 4 hours, which by those who did not consider this natural cause was looked upon as a prodigy.

627. But now it may be objected, that this course of the flood tide, east, or east north east, up the channel, is quite contrary to the hypothesis of the general motion of the tides being from east to west, and consequently of its being high water where the moon is vertical, or any where else in the meridian.

In answer. This particular direction of any branch of the tide doth not at all contradict the general direction of the whole; a River, whose course is west, may supply canals which may wind north, south, or even east, and yet the river keep its natural course; and if the river ebb and flow, the canals supplied by it would do the same, but not keep exact time with the river, because it would be flood, and the river advanced to some height, before the flood reached the further part of the canals, and the more remote, the longer time it would require; and it may be added, that if it was high water in the river just when the moon was on the meridian, she would be far past it, before it could be high water in the remotest part of those canals or ditches, and the flood would set according to the course of those canals that received it, and could not set west up a canal of a different position; and as *St. George's* channel, the *British* channel, &c. are no more in proportion to the vast ocean, than these canals are to a large navigable river; it will evidently follow, that among those obstructions and confinements, the flood may set upon any other point of the compass as well as west, and may make high water at any other time as well as when the moon is upon the meridian, and yet no way contradict the general theory of the tide before asserted.

628. From the observations of many persons, there have been collected the times when it is high water on the days of the new and full moons, on most of the sea coasts of *Europe*, and many other places: These times are usually put in a table against the names of the places digested in an alphabetical order; the like is followed in this work, only they are not given in a table by themselves, but make a column in the table of the Latitudes and Longitudes of places; which column is not filled up against many of the names in that table for want of a sufficient collection of observations: This may be supplied by those who have opportunity and inclination.

The use of such a Table is to find the time when it is high water at any of the places mentioned therein: But as this depends upon knowing
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the time when the moon comes to the meridian, and this on the moon's age, and this on the knowledge how to find some of the common notes in the Calendar; therefore it was thought convenient to introduce in this place a compendium of Chronology, wherein will be contained the several articles abovementioned.

SECTION VI.

Of Chronology.

629. **CHRONOLOGY** is the art of estimating, and comparing together, the times when remarkable events have happened, such as are related in history.

An **ÆRA** or **EPOCH**A is a time when some memorable transaction occurred; and from whence some nations date, and measure their computations of time.

	Years of the World.	Years before Christ.
Some have dated their events from the creation of the world. }	0000	4004
Others from the deluge or flood.	1656	2348
The Greeks from their Olympiads of 4 years each. }	3228	1776
The Romans from the building of Rome.	3251	753
The Astronomers from Nabonassar king of Babylon. }	3257	747
Some Historians from the death of Alexander the Great. }	3676	324
The Christians from the birth of Christ.	4004	A. D.
The Mahometans from the flight of Mahomet, and called the Hegira. }	4626	622

In order to assign the distance between these, and other events, the Ancients found it necessary to have a large measure of time, the limits of which was naturally pointed out to them by the return of the seasons, and this interval they called a year.

630. The most natural division of the year appeared to them to be the returns of the new moon; and as they observed 12 new moons to happen within the time of the general return of the seasons, they therefore first divided the year into 12 equal parts, which they called months: And as they reckoned about 30 returns of morning and evening between the times of the new moon and new moon, therefore they reckoned their month to consist of 30 days, and their year or 12 months to contain 360 days; and this is what is generally understood by the Lunar year of the Ancients.

631. But in length of time it was found that this year did not agree with the course of the sun, the seasons gradually falling later in the year than they had been formerly observed; this put them upon correcting
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the method of estimating their year, which they did from time to time, by taking a day or two from the month as often as they found it too long for the course of the moon; and by adding a month, called an intercalary month, as often as they found 12 Lunar months to be too short for the return of the four seasons and fruits of the earth: This kind of year so corrected from time to time by the Priests, whose business it was, is what is to be understood by the *Luni-solar* year; which was anciently used in most Nations, and is still among the *Arabs* and *Turks*.

As a great variety of methods were used in different countries to correct the length of the year, some by intercalating days in every year, and others by inserting months and days in certain returns or periods of years; and these different methods being observed by some eminent men to create a considerable difference in the accounts of time kept by neighbouring Nations, thereby introducing a confusion in the Chronological order of times, they therefore invented certain periods of years called *Cycles*, with which they compared the most memorable occurrences.

632. At length *Julius Cæsar* observing the confusion which this variety of accounts occasioned; and knowing that his order, as Emperor of the Romans, would be followed by a very considerable part of the world: He therefore, about 40 years before the birth of Christ, decreed that every fourth year should consist of 366 days, and the other three of 365 days each. This he did in consequence of the information given him by *Sysogenes* an eminent mathematician of Alexandria in Egypt; for at that time the philosophers of the Alexandrian school knew, from a length of experience, that the year consisted of about 365 days and a quarter; and this was the reason of ordering every fourth year to consist of 366 days, thereby compensating for the quarter day omitted in each of the preceding three years: This method, called the *Julian Account*, or *Old Style*, continued to be used in most Christian states until the year 1582.

The Astronomers since the time of *Julius Cæsar* have found that the true length of the Solar year, or common year, is 365 days 5 hours 48 minutes 55 seconds &c. being less than the Julian of 365 days 6 hours, by about 11 minutes 5 seconds, which is about the 130th part of 86400, the seconds contained in a day; so that in 130 Julian years there would be one day gained above 130 Solar years; consequently one day omitted in every 130 common years would bring the current account of time to agree very nearly with the motion of the sun.

633. In the year of our Lord 325, when the *council of Nice* settled the day for the celebration of Easter, the *Vernal Equinox* (that is the day in the spring when the sun rose at 6 and set at 6) happened on the 21st of March: But about the year 1580 the *Vernal Equinox* fell on the 11th of March, making a difference of about 10 days. Now *Gregory* the XIIIth, who was Pope at that time, observing that this difference of time in the falling out of the *Equinox* would affect the intention of the *Nicene council* concerning the time of the year appointed by them for the celebration of Easter: He therefore in the year 1581 published a *Bull*, ordering that in the year 1582 the 5th of October should be called the 15th, and so on; whereby the 10 days taken off would cause the time of the *Vernal Equinox* to fall on the 21st of March, as at the time of

the *Nicene council*. And to prevent any future difference, all the succeeding hundredth years divisible by 4, such as the years 1600, 2000, 2400, 2800, &c. should contain 366 days; and the centuries or hundredth years not divisible by 4, as 1700, 1800, 1900, 2100, &c. should contain only 365 days; the intermediate years to be reckoned as they used to be in the *Julian* or *Old Stile*. This Pope's alteration called the *Gregorian* or *New Stile*, was received in most of the Christian states: But some at that time chose to continue the *Julian*; among whom, the English in the year 1752 reformed their account, and introduced among themselves a new one, that nearly corresponds with the *Gregorian*.

A certain length of the year being once settled, and a regular account of time in consequence thereof being so fitted as to conform invariably to the seasons; it was natural for the States who received such account, to fit thereto a register of the days in each month, and therein to note the days when any remarkable occurrence was to be commemorated; and such register has obtained the name of *Calendar*.

634. The Calendar now in use among most of the Christian states consists of 12 months, called *January, February, March, April, May, June, July, August, September, October, November, December*; these months are called *civil*; the number of days in each may be readily remembered by the following rule.

635. Thirty days has *November, April, June* and *September*;

February has twenty eight alone, All the rest have thirty one,

When the year consists of 365 days: But in every fourth, which consists of 366 days, *February* has 29. This additional day was intercalated after the 24th of *February*, which in the old Roman Calendars was called the *sixth of the calends of March*, and being this year reckoned twice over, the year was called *Bissextile* or *LEAP YEAR*.

Beside the Months, time is also divided into Weeks, Days, Hours, Minutes, &c. a year containing 52 weeks, a week 7 days, a day 24 hours, an hour 60 minutes, &c.

In the Calendars it has been usual to mark the seven days of the week with the seven first letters of the Alphabet; always calling the 1st of *January* A, the 2d B, the 3d C, the 4th D, the 5th E, the 6th F, and the 7th G, and so on, throughout the year; and that letter answering to all the sundays for a year is called the *DOMINICAL LETTER*.

According to this disposition, the letters answering to the first day of every month in the year will be known by the following rule.

636. At Dover Dwells George Brown Esquire,

Good Christopher Finch And David Frier.

Where the first letter of each word answers to the letter belonging to the first day of the Months in the order from *January* to *December*.

637. A year of 365 days contains 52 weeks and 1 day; and a Leap year has 52 weeks and 2 days; therefore the first and last days of a common year fall on the same week day, suppose it *Monday*; then the next year begins on a *Tuesday*, the next year on *Wednesday*, and so on to the eighth year, which would be on *Monday* again, did every year contain 365 days; also the Dominical letter would run backwards thro' all the seven letters: But this round of seven years is interrupted by the Leap years; for herein *February* having a 29th day annexed, the first *Dominical*

nical letter in *March* must fall a day sooner than in the common year; so that Leap year has two Dominical letters, the one (supposing G) serving for *January* and *February*, and the other, which is the preceding letter (F) serves for the rest of the Sundays in that year.

638. The SOLAR CYCLE, or cycle of the sun, is a period of 28 years, in which all the varieties of the Dominical letters will have happened, and the same order of the letters will return as were 28 years before. At the birth of Christ 9 years had past in this cycle.

For the changes, were all the years common ones, would be 7,

But the interruptions by leap year being every fourth year;

Therefore the changes will be 4 times 7, or 28 years.

This return of the Dominical letters is constant in the *Julian* account: But in the *Gregorian*, where among the compleat centuries, or hundredth years, only every fourth is leap year; the other three hundredth years, which according to the *Julian* would be leap years, are by the *Gregorians* only common years of 365 days: in these all the letters must be removed one place forwards in a direct order; and either year, instead of having two Dominical letters (as suppose D, C) will have only one (as D), the dominical letters moving retrograde.

639. The LUNAR CYCLE, or the cycle of the moon, is a period of nineteen years, containing all the variations of the days on which the new and full moons happen; after which they fall on the same days they did 19 years before: But when a centesimal or hundredth year falls in the cycle, the new and full moons, according to the New Stile, will fall a day later than otherwise. The year of the birth of Christ was one year after the beginning of this cycle.

This cycle, sometimes called the *Metonic cycle*, from *Meton* an Athenian who invented it about 432 years before Christ, is not so perfect as was at first imagined by those who reckoned 19 solar years exactly equal to 235 lunations, or new moons; for by later observations the cycle is found less than 19 years, by one hour twenty eight minutes; whereby the new moons will, in 311 years, happen a day earlier than according to the Metonic account; and consequently all those festivals depending on the new moons, will in time be removed into different seasons of the year than at their first institution.

640. The PRIME, or GOLDEN NUMBER, is the number of years elapsed in this cycle. At the birth of Christ, the Golden number was 2.

641. The EPOCH of any year, is the Moon's age at the beginning of that year; that is, the days past since the last new moon.

The time between new moon and new moon is in the nearest round numbers $29\frac{1}{2}$ days; therefore the Lunar year consisting of 12 Lunations, must be equal to 354 days, which is 11 days less than the solar year of 365 days: Now supposing the Solar and Lunar years to begin together, the Epoch is 0, the beginning of the next solar year, the Epoch is 11; the 3d year the Epoch is 22, the 4th 33, &c. But when the Epoch exceeds 30, then an intercalary month of 30 days is added to the Lunar year, making it consist of 13 months; so that the Epoch at the beginning of the 4th year is only 3, the 5th 14, the 6th 25, the 7th 36, or only 6, on account of the intercalary month; and so on to the end of the cycle of 19 years; at the expiration whereof, the same Epochs would

run over again, was the cycle perfect ; and the Epact would always be 11 times the prime.

642. By the Nicene council it was enacted,

1st. That Easter day should be celebrated after the Vernal Equinox, which at that time happened on the 21st of March.

2d. That it should be kept after the 14th day of that moon which happened nearest to the 21st of March in common years, and nearest the 20th of March in Leap years.

3d. That the Sunday next following the 14th day should be Easter Sunday: which must always fall between the 20th or 21st of March, and the 25th of April.

643. The MOON'S SOUTHING at any place, is the time when she comes to the meridian of that place, which is every day later by about $\frac{4}{5}$ of an hour, or 48 minutes ; occasioned by the hours in a day being divided by the 30 times she passes the meridian from new moon to new moon.

The sun and moon come to the Meridian at the same time on the day of new moon or change ; also the moon comes to the opposite part of the same meridian, when in opposition, or at full moon : Hence between new and full, she comes to the meridian in the afternoon ; at full she souths at midnight, and after full at past midnight, or in the morning ; likewise when at change, she rises nearly with the sun ; at full she rises about the time the sun sets.

The motion of the tide is regulated by that of the moon, whose motion is 15 degrees an hour, or one point of the compass in 45 minutes.

644. The ROMAN INDICTION is a cycle of 15 years, used by the ancient Romans. Three years of this cycle was elapsed at the birth of Christ.

The DIONYSIAN PERIOD is a cycle of 532 years, arising by multiplying together 28 and 19, the solar and lunar cycles, and was contrived by *Dionysius Exiguus*, a Roman abbot, about the year of Christ 527, as a period for comparing of chronological events.

The JULIAN PERIOD contains 7980 years ; it arises by multiplying together 28, 19, 15, the cycles of the Sun, Moon and Indiction. This was also contrived as a period for chronological matters ; and its beginning is put 710 years before the usual date of the creation.

From the principles laid down in the preceding articles, depend the solution of the following Problems.

645. PROBLEM I. *To find whether any given year be Leap year.*

RULE. Divide the given year by 4, if 0 remains it is leap year ; if 1, 2, or 3 remains, it is so many years after.

Observing that the years 1800, 1900, 2100 &c. are common years.

Ex. I. *Is 1752 Leap year ?*

4)1752(438

Remains 0, so it is leap year.

Ex. II. *Is 1759 Leap year ?*

4)1759(439

Remains 3 years past leap year.

646. PROBLEM II. *To find the Dominical letter till the year 1800.*

RULE. To the given year add its fourth part, divide the sum by 7; the remainder taken from 7 leaves the index of the letter in common years; reckoning A 1, B 2, C 3, &c.

But in Leap years, this letter and its preceding one are the dominical letters.

Ex. I. *For the year 1753.*

$$\begin{array}{r} 4)1753 \\ 438 \\ \hline \end{array}$$

$$7)2191(313$$

Remains 0. Then $7 - 0 = 7 = G$.
So G is the Dom. letter.

Ex. II. *For the year 1756.*

$$\begin{array}{r} 4)1756 \\ 439 \\ \hline \end{array}$$

$$7)2195(313$$

Remains 4. Then $7 - 4 = 3 = C$.
So D, C, are the Dom. letters.

647. PROBLEM III. *To know on what week day any proposed day will fall.*

RULE. Find the dominical letter (646); Also the week day the 1st of the proposed month falls on (636); And hence the name of the proposed day of the month will be known, observing that the 1st, 8th, 15th, 22d and 29th days of any month fall on the same week day.

Ex. I. *In 1753 on what day of the week does the 12th of April fall?*

The dominical letter is G,
And the 1st of April is G,
Therefore April 8th is Sunday,
Consequently the 12th is Thursday.

Ex. II. *On what day of the week does 24th of September fall in 1756?*

The dominical letter is C,
And the 1st of Sept. is F or Wednesd.
Therefore the 22d is Wednesday,
Consequently the 24th is Friday.

648. PROBLEM IV. *To find the year of the Solar, Lunar and Indiction cycles.*

RULE. To the given year add 9 for the Solar, 1 for the Lunar, 3 for the Indiction: Divide the sums in order by 28, 19, 15; the remainder in each shews the year of its respective cycle.
(638, 639, 644)

EXAM. *Required the years of the Solar, Lunar and Indiction cycles for the year 1753?*

$$\begin{array}{r} 1753 \\ + 9 \\ \hline \end{array}$$

$$28)1762(62$$

Rem. 26 = Solar cycle.

$$\begin{array}{r} 1753 \\ + 1 \\ \hline \end{array}$$

$$19)1754(92$$

6 = } Lunar cycle,
or Gold. N°.

$$\begin{array}{r} 1753 \\ + 3 \\ \hline \end{array}$$

$$15)1756(117$$

1 = Indiction cycle.

Whereby it appears, { 26th year of the 63d Solar cycle
that the year 1753 { 6th year of the 93d Lunar cycle
is the { 1st year of the 118th Indiction cycle. } since the birth of Christ.

649. PROBLEM V. *To find the Epact till the year 1900.*

RULE. Multiply the golden number for the given year by 11, and divide the product by 30; from the remainder take 11, leaves the Epact.

If the remainder is less than 11, add 19 to it, and it gives the Epact.

Ex. I. *Find the Epact for 1753?*

The Golden N^o. is 6 (648)

Multiply by 11

30)66(2

Remains 6, less than 11.

Add 19

The sum 25 = Epact.

Ex. II. *Find the Epact for 1760?*

The Golden N^o. is 13, found by 648.

Multiply by 11

30)143(4

Remains 23, more than 11.

Subtract 11

Leaves 12 = Epact.

650. PROBLEM VI. *To find the Moon's age.*

RULE. To the Epact add the number, and day of the month; their sum, if under 30, is the Moon's age.

But if that sum is greater, 30 taken from it leaves the Moon's age.

The Moon's age taken from 30 leaves the day of the next change.

When the solar and lunar years begin together, the moon's age on the 1st of each month, or the monthly Epacts, are called the numbers of the month,

and are { 0 2 1 2 3 4 5 6 8 8 10 10
Jan. Feb. Mar. Apr. May. June. July. Aug. Sept. Oct. Nov. Dec.

Ex. I. *What is the Moon's age on the 21st of March 1753?*

The Epact is 25 (649)

The N^o of month 1

The day of month 21

The sum is 47

Take away 30

Leaves 17 = Moon's age.

Then $(30 - 17 =) 13$ days after the 21st of March, or Apr. 3d is new moon.

Ex. II. *What is the Moon's age on the 20th of March 1760?*

The Epact is 12. (649)

Then $12 + 1 + 20 = 33$ is the sum of the Epact, number and day of the month.

And $(33 - 30 =) 3 =$ the Moon's age.

Also $(30 - 3 =) 27$ days after the 20th of March, or April the 16th is the day of the next new moon.

651. PROBLEM VII. *To find when Easter day will happen.*

RULE. Find the Moon's age on March 21st in common years, or on March 20th in leap years; and if it be 14, find the week day, and the Sunday following is Easter day.

If the Moon's age is not 14, reckon as many days forward as make 14; find the corresponding week day, and the next Sunday following is Easter day.

Ex.

Ex. I. *On what day does Easter Sunday fall in the year 1753?*

For 1753 the dom. letter is G. (646)
On Mar. 21 the Moon's age is 17 (650)
The next new moon is on Apr. 3d.
And 14th day is on April 16.
April the 1st is G, or Sunday. (647)
April the 16th is Monday.
Then Easter Sunday is Apr. 22d.

Ex. II. *Required the time of Easter day in the year 1760?*

For 1760 the dom. letter is E. (646)
On Mar. 20 the Moon's age is 3. (650)
So that the nearest new moon to Mar. 20th falls on the 18th, and the 14th day of that Moon is Mar. 31.
Mar. 1st is D, or Saturday. (647)
Then the 31st is Monday.
And the next Sunday or Easter day is on April the 6th.

652. PROBLEM VIII. *To find the time of the Moon's southing.*

RULE. Multiply the Moon's age by 4, the product divided by 5, quotes the hours, and the remainder multiplied by 12 gives the additional minutes.

If this time is less than 12 hours, it is the time of the southing after midday: But if greater, 12 hours taken from it, leaves the southing after midnight.

Ex. I. *At what time does the moon come to the meridian, Mar. 21, 1753?*
The Moon's age is 17 days (650)

$$\begin{array}{r} 4 \\ \hline 5 \overline{) 68} (13 \text{ h. } 36 \text{ m.} \\ \hline \text{Remains } 3 \\ 12 \\ \hline 36 \text{ min.} \\ \hline \end{array}$$

Answer, at 1 h. 36 m. in the morning.

Ex. II. *Required the time of the moon's southing on the 20th of March, 1760?*
The Moon's age is 3 days (650)

$$\begin{array}{r} 4 \\ \hline 5 \overline{) 12} (2 \text{ h. } 24 \text{ m.} \\ \hline \text{Remains } 2 \\ 12 \\ \hline 24 \text{ min.} \\ \hline \end{array}$$

Answer, at 2 h. 24 m. in the afternoon.

653. PROBLEM IX. *To find the time of high water at any place.*

RULE. To the time of the moon's southing, add the time the moon has passed the meridian to make high water at that place; and the sum shews the time of high water.

The distance of the moon from the meridian when high water, is found in the right hand column of the Table, art. 659, against the name of the place.

Ex. I. *On the 21st of March, 1753, at what time is it high water at London?*

The moon souths at 1 h. 36 m. A.M. * (652)

At Lond. D bears } 3 00
N. E. or S. W.

The sum gives the } 4 36 A. M.
time of high water.

* A. M. signifies before noon, or morning.

Ex. II. *Required the time when it is high water at Ushant March 20, 1760?*

The moon souths at 2 h. 24 m. P. M. † (652)

At Ushant D bears } 3 45 past the Mer.
N. E. by E. and }
S. W. by W. or is }

H. water at Ushant 6 09 P. M.

† P. M. signifies after noon, or evening.

SECTION

S E C T I O N VII.

Geographical Problems.

654. PROBLEM I. *Given the latitudes of two places,
Required their difference of latitude.*

CASE I. When the latitudes of the given places have the same name.

RULE. Subtract the lesser latitude from the greater, the remainder is the difference of latitude.

EXAM. I. *What is the difference of latitude between London and Rome?*

London's lat. $51^{\circ} 32' N.$

Rome's lat. $41^{\circ} 54' N.$

Diff. lat. $\begin{array}{r} 9\ 38 \\ 60 \end{array}$

578 miles.

EXAM. II. *What is the difference of latitude between the Lizard and the Island of Madeira?*

Lizard's lat. $49^{\circ} 57' N.$

Madeira's lat. $32^{\circ} 38' N.$

Diff. lat. $\begin{array}{r} 17\ 19 \\ 60 \end{array}$

1039 miles.

EXAM. III. *What is the difference of latitude between the Island of St. Helena and the Cape of Good Hope?*

C. Good Hope's lat. $34^{\circ} 15' S.$

St. Helena's lat. $16^{\circ} 00' S.$

Diff. lat. $\begin{array}{r} 18\ 15 \\ 60 \end{array}$

1095 miles.

EXAM. IV. *A ship from the latitude of $43^{\circ} 18' N.$ is come to the lat. of $34^{\circ} 49' N.$ Required the diff. of latitude?*

Lat. from $43^{\circ} 18' N.$

Lat. in $34^{\circ} 49' N.$

Diff. lat. $\begin{array}{r} 8\ 29 \\ 60 \end{array}$

509 miles.

CASE II. When the latitudes of the given places have contrary names.

RULE. Add the latitudes together, and the sum will be the difference of latitude.

EXAM. I. *Required the diff. of lat. between C. Finisterre and C. St. Roque?*

C. Finisterre lat. $43^{\circ} 15' N.$

C. St. Roque lat. $5^{\circ} 00' S.$

Diff. lat. $\begin{array}{r} 48\ 15 \\ 60 \end{array}$

2895 miles.

EXAM. II. *What is the difference of latitude between the Island of Barbados and C. Negro?*

I. of Barbados's lat. $13^{\circ} 00' N.$

C. Negro's lat. $16^{\circ} 30' S.$

Diff. lat. $\begin{array}{r} 29\ 30 \\ 60 \end{array}$

1770 miles.

EXAM. III. *Required the difference of latitude between C. Horn and C. Corientes in Mexico?*

Cape Horn's lat. $55^{\circ} 42' S.$

C. Corientes's lat. $20^{\circ} 18' N.$

Diff. lat. $\begin{array}{r} 76\ 00 \\ 60 \end{array}$

4560 miles.

EXAM. IV. *A ship from the lat. of $8^{\circ} 28' S.$ has sailed north to the lat. $6^{\circ} 45' N.$ Required the diff. of latitude?*

Lat. from $8^{\circ} 28' S.$

Lat. in $6^{\circ} 45' N.$

Diff. lat. $\begin{array}{r} 15\ 13 \\ 60 \end{array}$

913 miles.

655. PROBLEM II. *Given the latitude of one place, and the difference of latitude between it and another place:
Required the latitude of the other.*

CASE I. When the given latitude and difference of latitude have the same name.

RULE. To the given latitude, add the degrees and minutes in the diff. of latitude, that sum is the other latitude, of the same name.

EXAM. I. *A ship from the latitude of $38^{\circ} 14'$ N. sails north till her difference of latitude is $12^{\circ} 32'$: What latitude is she come to?*

Lat. from	$38^{\circ} 14' \text{ N.}$
Diff. lat.	$12 \quad 32 \text{ N.}$

Lat. in	$50 \quad 46 \text{ N.}$
---------	--------------------------

EXAM. II. *A ship from the Island of Ascension runs south till her diff. of latitude is $5^{\circ} 37'$: What is the present latitude of the ship?*

I. Ascension's lat.	$7^{\circ} 41' \text{ S.}$
Diff. lat.	$5 \quad 37 \text{ S.}$

Ship's lat.	$13 \quad 18 \text{ S.}$
-------------	--------------------------

EXAM. III. *A ship from the Island of Madeira sails N. 675 miles: What latitude is she in?*

I. Madeira's lat.	$32^{\circ} 38' \text{ N.}$
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Diff. lat.	$\frac{675}{60} (22) = 11 \quad 15 \text{ N.}$
------------	--

Ship's lat.	$43 \quad 53 \text{ N.}$
-------------	--------------------------

EXAM. IV. *Three days ago we were in the latitude of the Cape of Good Hope, and have run each day 92 miles directly S. What is our present latitude?*

C. Good Hope's lat.	$34^{\circ} 15' \text{ S.}$
---------------------	-----------------------------

Diff. lat.	$\frac{92 \times 3}{60} (22) = 4 \quad 36 \text{ S.}$
------------	---

Present latitude	$38 \quad 51 \text{ S.}$
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CASE II. When the given latitude and difference of latitude have contrary names.

RULE. Take the difference between the given latitude and the degrees and minutes in the diff. of latitude, the remainder is the other latitude, of the same name with the greater.

EXAM. I. *A ship from the latitude of $38^{\circ} 14'$ N. sails south till her difference of latitude is $12^{\circ} 32'$: What latitude is she come to?*

Lat. from	$38^{\circ} 14' \text{ N.}$
Diff. lat.	$12 \quad 32 \text{ S.}$

Lat. in	$25 \quad 42 \text{ N.}$
---------	--------------------------

EXAM. II. *A ship from the Island of Ascension runs north till her diff. lat. is $5^{\circ} 37'$: What is the present latitude of the ship?*

I. Ascension's lat.	$7^{\circ} 41' \text{ S.}$
Diff. lat.	$5 \quad 37 \text{ N.}$

Ship's lat.	$2 \quad 04 \text{ S.}$
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EXAM. III. *A ship from Sierra Leona sails S. 839 miles: What latitude is she in?*

Sierra Leona's lat.	$8^{\circ} 30' \text{ N.}$
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Diff. lat.	$\frac{839}{60} (22) = 13 \quad 59 \text{ S.}$
------------	--

Ship's lat.	$5 \quad 29 \text{ S.}$
-------------	-------------------------

EXAM. IV. *Four days ago we were in the latitude of the Island of St. Mathew, and sailed due north 6 miles an hour: What latitude is the ship in?*

St. Mathew's lat.	$1^{\circ} 23' \text{ S.}$
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Diff. lat.	$\frac{6 \times 24 \times 4}{60} (22) = 9 \quad 36 \text{ N.}$
------------	--

Ship's latitude	$8 \quad 13 \text{ N.}$
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D d

656.

656. PROBLEM III. *Given the longitudes of two places,
Required the difference of longitude.*

RULE. If the longitudes are of the same name, their difference is the difference of longitude required.

But if the longitudes are of different names, their sum gives the difference of longitude.

And if this sum exceeds 180 degrees, take it from 360 degrees, and there remains the difference of longitude.

EXAM. I. *Required the difference of longitude between London and Naples?*

London's long. $00^{\circ} 00' E.$
Naples's long. $14^{\circ} 45' E.$

Diff. longitude $14^{\circ} 45'$
 60

885 miles.

EXAM. II. *A ship in longitude $14^{\circ} 45' W.$ is bound to a port in longitude $48^{\circ} 18' W.$ What diff. of longitude must she make?*

Ship's long. $14^{\circ} 45' W.$
Long. bound to $48^{\circ} 18' W.$

Diff. longitude $33^{\circ} 33'$
 60

2013 minutes.

EXAM. III. *What is the difference of longitude between Cape Gardafuir and Cape Comorin?*

C. Gardafuir's long. $50^{\circ} 25' E.$
C. Comorin's long. $78^{\circ} 17' E.$

Diff. longitude $27^{\circ} 52'$
 60

1672 minutes.

EXAM. IV. *Required the diff. of longitude between St. Christopher's and Cape Negro?*

St. Christopher's long. $62^{\circ} 50' W.$
C. Negro's long. $11^{\circ} 30' E.$

Diff. longitude $74^{\circ} 20'$
 60

4460 minutes.

EXAM. V. *A ship in longitude $140^{\circ} 20' W.$ is bound to a place in longitude $139^{\circ} 35' E.$ What diff. of longitude must she make?*

Ship's long. $140^{\circ} 20' W.$
Long. bound to $139^{\circ} 35' E.$

$279^{\circ} 55'$
 $360^{\circ} 00'$

Diff. long.

$80^{\circ} 05'$

EXAM. VI. *What is the difference of longitude between Cape Horn and the Straits of Manila?*

C. Horn's long. $66^{\circ} 00' W.$
Str. Manila's long. $124^{\circ} 00' E.$

$190^{\circ} 00'$
 $360^{\circ} 00'$

Diff. longitude

$170^{\circ} 00'$

657. Sometimes the diff. long. between two places is estimated by the diff. of time, allowing an hour to every 15 degrees of longitude, and one min. of time for every 15 min. of a deg. or a deg. for every 4 min. of time.

EXAM. *Having at 6 h. 48 m. P. M. observed at sea a certain appearance in the heavens, which I know was seen the same instant at 3 h. 25 m. P. M. in London: Required the diff. longitude between the places of observation.*

From 6 h. 48 m.

Take $3^{\circ} 35'$

Leaves $3^{\circ} 13' =$ diff. time.

$3^{\circ} = 45^{\circ}$ deg.

$13^{\circ} = 3^{\circ} 15'$

Sum $48^{\circ} 15' =$ diff. longitude.

And because the hour of appearance at London was less, therefore I know myself to be to the eastward of London.

658-

658. PROBLEM IV. *Given the longitude of one place, and the difference of longitude between that and another :
Required the longitude of the second place.*

RULE. If the given longitude and difference of longitude are of a contrary name, their difference is the longitude required ; and is of the same name with the greater.

But if the given longitude and difference of longitude are of the same name, the sum is the longitude sought, of the same name with the given place.

And if the sum is greater than 180 degrees, take it from 360 degrees, remains the longitude required, of a contrary name with that of the given place.

EXAM. I. *A ship from the longitude of $41^{\circ} 12' E.$ sails westward until her difference of longitude is $15^{\circ} 47'$: What is her present longitude ?*

Ship's longitude	$41^{\circ} 12' E.$
Diff. long.	$15 \quad 47 \quad W.$
Present long.	$25 \quad 25 \quad E.$

EXAM. II. *A ship from Cape Charles in Virginia sails eastward until she has altered her longitude $22^{\circ} 53'$: What longitude is she in ?*

C. Charles's long.	$76^{\circ} 07' W.$
Diff. long.	$22 \quad 53 \quad E.$
Ship's long.	$53 \quad 14 \quad W.$

EXAM. III. *Four days ago I departed from C. St. Sebastian in Madagascar, and I have made each day 75 miles of E. longitude : Required the longitude the ship is in ?*

75	
4	C. Sebas. long. $49^{\circ} 13' E.$
	Diff. long. $5 \quad 00 \quad E.$
6,0)30,0	
	Ship's long. $54 \quad 13 \quad E.$
5 0	

EXAM. IV. *A ship from Cape Finisterre sails westward, and finds she has altered her longitude 587 miles : What longitude is she arrived in ?*

C. Finisterre's long.	$9^{\circ} 20' W.$
Diff. long. $\frac{587}{60}$	$9 \quad 47 \quad W.$
Long. in	$19 \quad 07 \quad W.$

EXAM. V. *A ship from Cape St. Lucar in California has made $87^{\circ} 18'$ of west longitude : What longitude is she in ?*

C. Lucar's long.	$111^{\circ} 35' W.$
Diff. long.	$87 \quad 18 \quad W.$
	$198 \quad 53 \quad W.$
	$360 \quad 00$
Ship's longitude	$161 \quad 07 \quad E.$

EXAM. VI. *Seven days ago my longitude was $172^{\circ} 17' W.$ and I have made each day 132 miles of west longitude : Required my present longitude ?*

132	Departed long. $172^{\circ} 17' W.$
7	Diff. long. $15 \quad 24 \quad W.$
6,0)92,4	$187 \quad 41$
	$360 \quad 00$
15 24	
Present long.	$172 \quad 19 \quad E.$

659.

A T A B L E

Containing the Latitudes and Longitudes of the chief towns, islands, bays, capes and other parts of the sea coasts in the known world; collected from the most authentic observations and charts extant; with the times of high water on the days of the new and full moon.

The longitudes are reckoned from the meridian of London. By the Latitude and Longitude of an island or harbour is meant the middle of that place.

Note, B. stands for bay; C. for cape; R. for river; Po. for port; Pt. for point; I. for isle; St. for saint; G. for gulf; M. for mount; Eu. for Europe; As. for Asia; Af. for Africa; Am. for America; Atl. for Atlantic; Ind. for Indian; Med. sea, for Mediterranean sea; Wh. sea, for White sea; Archip. for Archipelago; Nov. Sco. for Nova Scotia; Phil. I. for Philippine Isles; Adriat. for Adriatic; Eng. for England: Beside other contractions which will be easily understood.

Names of places.	Con	Country	Coast.	Latitude.	Longitud.	H. Water.
A						
I. Abacco {	N. pt.	Am.	Bahama I.	Atl. Ocean	27 12 N.	77 05 W
or Lucayos {	S. pt.				26 15 N.	77 01 W
Abbrevrak	Eu.	France	Eng. Chan.	48 32 N.	4 15 W	4h. 30m.
St. Abbshhead	Eu.	Scotland	Germ. Ocean	55 55 N.	1 56 W	
I. Abdeleur	Af.	Anian	Indian Sea	11 55 N.	51 45 E.	
Aberdeen	Eu.	Scotland	Germ. Ocean	57 06 N.	01 44 W	o 45
Abo	Eu.	Finland	Bal. Sea	60 30 N.	21 30 E.	
Abrolhos bank	Am.	Brazil	Atl. Ocean	18 22 S.	38 45 W	
Abrollo bank N. pt.	Am.	Bahama	Atl. Ocean	21 33 N.	69 50 W	
Acapulco. See A quapulco.						
Achen	Af.	I. Sumatra	Ind. Ocean	5 15 N.	95 55 E.	
Aden	Af.	Arabia	Indian Sea	12 55 N.	45 35 E.	
I. Admiralties	Eu.	Nov Zem	N. Ocean	75 05 N.	52 50 E.	
I. Agalega or Gallega	Af.	Madagas.	Ind. Ocean	10 15 S.	54 46 E.	
C. St. Agnes	Am.	Patagon	S. Atl. Ocean	53 55 S.	62 47 W	
Agra	Af.	India	Moguls	26 43 N.	76 49 E.	
I. St. Agusta	Eu.	Dalmatia	Adriat. Sea	42 40 N.	18 57 E.	
C. Ajuga	Am.	Peru	S. Ocean	6 38 S.	80 50 W	
B. Alagoa	Af.	Cassers	S. Ocean	25 30 S.	33 33 E.	
If. Aland	Eu.	Sweden	Balt. Sea	60 20 N.	21 30 E.	
R. Albany	Am.	New SWales	Hud. Str.	52 35 N.	85 18 W	
I. Alboran	Af.	Algier	Medit. Sea	36 00 N.	2 27 W	
Aldborough	Eu.	England	Germ. Ocean	52 20 N.	1 25 E	9 45
I. Alderney	Eu.	England	Eng. Chan.	49 48 N.	2 11 W	12 00
Aleppo	Af.	Syria	Medit. Sea	35 45 N.	36 25 E.	
Alexandretta	Af.	Syria	Medit. Sea	36 35 N.	36 25 E.	
Alexandria	Af.	Egypt	Medit. Sea	31 11 N.	30 21 E	
I. Algeranca	Af.	Canaries	Atl. Ocean	29 45 N.	12 13 W	
Algier	Af.	Algier	Medit. Sea	36 49 N.	2 18 E	
Alicant	Eu.	Spain	Medit. Sea	38 34 N.	0 07 W	
I. Alicur, Lipari Is.	Eu.	Italy	Medit. Sea	38 31 N.	14 37 E.	

Alkolia

Names of Places.	Con.	Countries.	Coast.	Latitude.	Longitud.	H. Water.
Alkofir	Af.	Egypt	Red Sea	26 20 N.	34 41 E.	
B. All Saints, or Todos, Sanctos	Am.	Brazil	Atl. Ocean	13 05 S.	38 45 W.	
Almeria	Eu.	Spain	Medit. Sea	36 51 N.	2 15 W.	
Is. Almirante, limits	Af.	Zanguebar	Ind. Ocean	5 45 S. 4 30 S.	52 30 E. 55 40 E.	
Altur	Af.	Arabia	Red Sea	28 20 N.	34 19 E.	
R. Amazons, mouths	Am.	Terra Fir.	Atl. Ocean	0 30 S.	47 35 W. 49 20 W.	6h. 00m.
I. Amboyna	Af.	Moluc. I.	Ind. Ocean	4 25 N.	127 25 E.	
Is. Ambrosa	Am.	Chili	S. Ocean	25 30 S.	83 20 W.	
I. Ameyland	Eu.	Dutch Ind.	Germ. Oce.	53 30 N.	6 20 E.	7 30
I. Amoy	Af.	China	S. Ocean	24 30 N.	118 45 E.	
Amsterdam	Eu.	Dutch Ind.	Germ. Oce.	52 23 N.	05 04 E.	3 00
I. Amsterdam	Af.	S. Contin.	Ind. Ocean	37 55 S.	75 15 E.	
I. Amsterdam	Af.	S. Contin.	S. Ocean	21 25 S.	179 41 W.	
I. Anabona	Af.	Eth. coast	Atl. Ocean	2 36 S.	5 35 E.	
Ancona	Eu.	Italy	Mediterran.	43 54 N.	14 20 E.	
Is. Andaman, limits	Af.	India	B. Bengal	14 00 N. 10 08 N.	93 05 E. 93 35 E.	
I. Andaro	Af.	India	Ind. Ocean	10 00 N.	73 40 E.	
I. St. Andero Sotovento	Am.	Mexico	Atl. Ocean	12 30 N.	81 35 W.	
C. St. Andrea	Af.	Madagaf.	Ind. Ocean	15 46 S.	45 22 E.	
St. Andrews	Eu.	Scotland	Germ. Oce.	56 18 N.	2 37 W.	2 15
Is. An- drofs	N. pt. S. pt.	Am. Bahama I.	Atl. Ocean	25 00 N. 23 30 N.	77 58 W. 77 00 W.	
Is. Angafay	Af.	Madagaf.	Ind. Ocean	17 00 S.	58 40 E.	
C. St. Angelo	Eu.	Turkey	Archipelago	36 27 N.	33 38 E.	
Mount St. Angelo	Eu.	Italy	Med. Sea	41 42 N.	16 16 E.	
R. d'Angra	Af.	Ethiopia	N. Atl. Oce.	01 00 N.	9 35 E.	
C. d'Anguilhas	Af.	Caffers	Ind. Ocean	34 45 S.	21 40 E.	
I. Anguilla	Am.	Antil. Is.	Atl. Ocean	18 15 N.	62 57 W.	
I. Anholt	Eu.	Denmark	Sound	56 40 N.	12 00 W.	0 00
C. Ann	Am.	New Eng.	W. Ocean	42 50 N.	70 27 W.	
C. Queen Ann	Am.	Groenlnd.	N. Ocean	64 15 N.	50 30 W.	
Q. Ann's Foreland	Am.	N. Main	Hudson's Str.	64 08 N.	74 36 W.	
Annapolis Royal	Am.	N. Scotia	B. Fundy	45 00 N.	64 00 W.	
I. Antego	Am.	Caribbe I.	Atl. Ocean	16 57 N.	61 50 W.	
Antibes	Eu.	France	Medit. Sea	43 34 N.	07 13 E.	
I. Ante- cost	W. pt. E. pt.	Am. Canada	B. St. Lau- rence	50 00 N. 49 33 N.	62 08 W. 59 35 W.	
Antiochetta	Af.	Syria	Medit. Sea	36 08 N.	36 17 E.	
C. d'Antifer	Eu.	France	Eng. Chan.	49 47 N.	0 34 E.	
C. Antonio	Am.	I. Cuba	Atl. Ocean	21 45 N.	84 05 W.	
I. St. Antonio	Af.	Cape Verd	Atl. Ocean	17 45 N.	24 23 W.	
C. St. Antony	Am.	Magellan	S. Atl. Oce.	36 45 S.	53 42 W.	
Antwerp	Eu.	Flanders	R. Scheld	51 13 N.	4 29 E.	6 00
B. Apalaxy	Am.	Florida	G. Mexico	30 00 N.	83 53 W.	
I. Apalioria	Af.	India	Ind. Ocean	9 08 S.	79 40 E.	

Aquapulco

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Aquapulco	Am.	Mexico	S. Sea	17 10N.	101 40W	
Aquatulco	Am.	Mexico	S. Sea	15 27N.	96 03W	
Archangel	Eu.	Russia	White Sea	64 30N.	41 30E.	6h. 00m.
I. d'Areas	Am.	Mexico	G. Mexico	20 45N.	92 35W	
Arica	Am.	Peru	S. Sea	18 27 S.	71 05W	
I. Arran	Eu.	Ireland	St. Geo. Ch.	54 48N.	8 59W	
I. Ascending	Am.	Brazil	S. Atl. Oce.	20 42 S.	28 30W	
I. Ascension	Am.	Brazil	S. Atl. Oce.	7 41 S.	13 31W	7.57. Caille
I. Affinaria, Sardinia	Eu.	Italy	Medit. Sea	41 06N.	8 36 E.	
R. Ashley	Am.	Carolina	Atl. Ocean	33 22N.	79 50W	
R. Affene	Af.	Guinea	S. Atl. Oce.	5 30N.	2 20W	
I. Astores	Af.	Madagas.	Ind. Ocean	10 22 S.	53 25 E.	
Athens	Eu.	Turkey	Archipelago	37 40N.	24 10 E.	
Atkin's Key	Am.	Bahama I.	Atl. Ocean	22 07N.	73 46W	
Atwood's Keys	Am.	Bahama I.	Atl. Ocean	21 22N.	72 40W	
C. Ava	Af.	Japon	S. Ocean	34 45N.	141 00 E.	
Is. Aves, Sotovent	Am.	Ter. Fir.	Atl. Ocean	11 30N.	66 43W	
C. St. Augustine	Am.	Brazil	Atl. Ocean	8 48 S.	35 00W	
C. St. Augustine	Af.	Mindanao	S. Ocean	6 40N.	126 25 E.	
St. Augustine	Am.	Florida	Atl. Ocean	30 15N.	80 29W	
Aydhah	Af.	Egypt	Red Sea	21 53N.	36 26 E.	
Aylah	Af.	Arabia	Red Sea	29 08N.	35 41 E.	
B						
Babelmondel Straits	Af.	Abyssinia	Red Sea	12 50N.	43 50 E.	
C. Baba	Af.	Natolia	Archipelago	39 33N.	26 22 E.	
I. Bachian	Af.	Molucca I.	S. Sea	00 40N.	123 00 E.	
I. Bahama	Am.	Baha. Is.	Atl. Ocean	26 45N.	78 35W	
Bahama Bank, N. pt.	Am.	Baha. Is.	Atl. Ocean	27 50N.	78 43W	
Balafor	Af.	India	B. Bengal	20 00N.	79 54 E.	
Baldivia	Am.	Chili	S. Ocean	39 38 S.	72 45W	
I. Bali	Af.	Sunda Is.	Ind. Ocean	8 05 S.	114 30 E.	
Baltimore	Eu.	Ireland	W. Ocean	51 16N.	9 26W	4 30
I. Banca { S. end N.W. end	Af.	Sunda Is.	Ind. Ocean	{ 3 15 S. 1 50 S.	{ 107 10 E. 105 30 E.	
I. Banda	Af.	Molucc. Is.	Ind. Ocean	04 30N.	127 25 E.	
Banjar	Af.	I. Borneo	Ind. Ocean	2 27 S.	113 50 E.	
Bantam	Af.	I. Java	Ind. Ocean	6 15 S.	106 25 E.	
B. Bantry	Eu.	Ireland	Atl. Ocean	51 45N.	10 46W	
I. Barbadoes, { Bridge town	Am.	Carib. Is.	Atl. Ocean	13 00N.	59 50W	
C. Barbas	Af.	Sanaga	N. Atl. Oce.	21 50N.	16 26W	
I. Barbuda	Am.	Carib. Is.	Atl. Ocean	18 06N.	61 35W	
C. Barcam	Eu.	Greenland.	N. Ocean	78 18N.	20 06 E.	
Barcelona	Eu.	Spain	Medit. Sea	41 26N.	2 18 E.	
C. Barfleur	Eu.	France	Eng. Chan.	49 38N.	1 16W	8 00
Bargazar Point	Eu.	Iceland	N. Ocean	66 30N.	17 12W	
I. Bardsey	Eu.	Wales	St. Geo. Ch.	52 44N.	5 00W	
C. Barfo	Eu.	Russia	White Sea	66 30N.	38 00 E.	I. Bar-

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
I. Bartholomew	Am.	Carib. Is.	Atl. Ocean	17 52N.	62 35W	
I. de Bas	Eu.	France	Eng. Chan.	48 50N.	4 00W	3h. 45m.
Baffora	Af.	Arabia	Perf. Gulf	29 45N.	47 40 E.	
C. Baffos, or Baxos	Af.	Anian	Ind. Sea	4 12N.	47 07 E.	
Baffos de Banhos	Af.	Zangueb.	Ind. Ocean	5 00 S.	48 08 E.	
Baffos de Chagos	Af.	India	Ind. Ocean	6 42 S.	68 20 E.	
I. Baffos des Indes	Af.	Zangueb.	Ind. Ocean	21 19 S.	41 43 E.	
Batavia	Af.	I. Java	Ind. Ocean	6 15 S.	106 15 E.	
Bayonne	Eu.	France	B. Biscay	43 30N.	1 23 W	3 30
Bayona Isles	Eu.	Spain	Atl. Ocean	41 45N.	9 01W	
Beachy Head	Eu.	England	Engl. Chan.	50 48N.	0 25 E.	6 00
Bear-bay	Eu.	Greenlnd.	N. Ocean	79 10N.	24 15 E.	
I. Beerenberg	Eu.		N. Ocean	71 45N.	4 30 E.	
Belfast	Eu.	Ireland	Irish Sea	54 43N.	5 52W	
Bell Isle	Eu.	France	B. Biscay	47 21N.	3 13W	1 39
Str. Bell Isle	Am.	Newfland	Atl. Ocean	51 48N.	51 08W	
Bell Sound	Eu.	Greenlnd.	N. Ocean	77 15N.	12 40 E.	
Bencola	Af.	I. Sumat.	Ind. Ocean	4 00 S.	102 55 E.	
Bengal	Af.	India	B. Bengal	22 00N.	92 45 E.	
Bergen	Eu.	Norway	W. Ocean	60 10N.	6 14 E.	
Berlin	Eu.	Germany	R. Elbe	52 33N.	13 32 E.	
I. Bermudas	Am.	Baha. Is.	Atl. Ocean	32 25N.	66 38W	7 00
I. Bermaja	Am.	Mexico	G. Mexico	21 40N.	92 53W	
Berwick	Eu.	England	Germ. Oce.	55 45N.	1 50W	1 30
Berry Point	Eu.	England	Eng. Chan.	50 37N.	3 49W	
Bilboa	Eu.	Spain	B. Biscay	43 26N.	3 18W	
Blackney	Eu.	England	Germ. Oce.	53 20N.	0 55 E.	6 00
Black Point	Eu.	Greenlnd.	N. Ocean	78 00N.	10 50 E.	
Black Isle	Eu.	No. Zem.	N. Ocean	72 52N.	52 35 E.	
C. Blanco	Af.	NegroInd.	Atl. Ocean	20 45N.	17 23W	9 45
C. Blanco	Am.	Patagonia	Atl. Ocean	47 07 S.	64 05W	
C. Blanco	Eu.	Greenlnd.	N. Ocean	77 58N.	20 04 E.	
C. Blanco	Am.	Mexico	S. Sea	9 42N.	85 55W	
I. Blanco, Sotovento	Am.	Ter.Firm.	Atl. Ocean	11 42N.	64 20W	
Blanchart Race	Eu.	France	Eng. Chan.	49 42N.	2 08W	0 00
Blasques	Eu.	Ireland	Atl. Ocean	52 00N.	11 56W	
Blavet, or Port Louis	Eu.	France	B. Biscay	47 45N.	3 13W	1 30
Bocachica	Am.	Ter.Firm.	Atl. Ocean	10 20N.	75 30W	
C. Bojador	Af.	NegroInd.	Atl. Ocean	26 12N.	13 27W	0 00
R. Bolshaya	Af.	Siberia	S. Sea	52 48N.	157 00 E.	
I. Bombay	Af.	India	Ind. Ocean	19 42N.	73 03 E.	
Bona	Af.	Tunis	Mediterran.	37 08N.	7 10 E.	
C. Bona	Af.	Tunis	Mediterran.	37 10N.	10 00 E.	
C. Bona vista	Am.	Newfland	Atl. Ocean	49 36N.	50 10W	
I. Bona vista	Af.	C. Verd I.	Atl. Ocean	10 05N.	21 50W	
C. Bona fortuna	Eu.	Russia	White Sea	65 35N.	38 25 E.	
I. Bon ayre, Sotovento	Am.	Ter.Firm.	Atl. Ocean	11 52N.	67 20W	
B. Bonaventura	Am.	Ter.Firm.	S. Sea	3 18N.	76 50W	
C. Bon Esperance	Af.	Cassers	Ind. Ocean	34 15N.	20 07 E.	3 00
Bordeaux	Eu.	France	B. Biscay	44 50N.	0 40W	3 00

S. Borneo

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Isl. Borneo { East. point	Af.		Ind. Ocean	1 12 N.	117 10 E.	
West. point				3 15 N.	108 57 E.	
North. point				7 05 N.	113 40 E.	
South. point				3 32 S.	112 05 E.	
Borneo				5 00 N.	112 15 E.	
Succadano				0 50 S.	108 35 E.	
I. Bornholm	Eu.	Sweden	Balt. Sea	55 12 N.	15 50 E.	
Boston	Eu.	England	Germ. Oce.	53 10 N.	0 25 E.	
Boston	Am.	New Eng.	Atl. Ocean	42 34 N.	70 25 W.	
Boulogne	Eu.	France	Eng. Chan.	50 44 N.	1 42 E.	10h. 30m.
I. Bourbon	Af.	Madagaf.	Ind. Ocean	21 15 S.	55 40 E.	
I. St. Brandon	Af.	Madagaf.	Ind. Ocean	16 45 S.	64 48 E.	
B. Brandwyns	Eu.	Greenlnd.	N. Ocean	79 50 N.	26 20 E.	
I. Bravas	Af.	C. Verd I.	Atl. Ocean	14 30 N.	23 44 W.	
Bremen	Eu.	Germany	R. Weser	53 30 N.	9 00 E.	6 00
Breesound, a sand	Eu.	Dutchlnd.	Germ. Oce.	53 12 N.	5 15 E.	4 30
Breslau	Eu.	Silesia	R. Oder	51 03 N.	17 13 E.	
Brest	Eu.	France	B. Biscay	48 23 N.	4 26 W.	3 45
B. Brest	Am.	New Brit.	W. Ocean	52 10 N.	52 30 W.	
Bridge Town	Am.	I. Barbado.	Atl. Ocean	13 00 N.	59 50 E.	
Bridlington Bay	Eu.	England	Germ. Oce.	54 07 N.	00 04 E.	3 45
Brill	Eu.	Dutchlnd.	Germ. Oce.	51 56 N.	4 10 W.	
Bristol	Eu.	England	St. Geo. Ch.	51 28 N.	2 30 W.	6 45
I. Cape Britain { Louisbourg	Am.	Acadia	Atl. Ocean	45 50 N.	58 27 W.	
I. Scateri				46 00 N.	57 47 W.	
N. Cape				47 06 N.	58 02 W.	
I. Mathias	Af.	New Guinea	S. Ocean	2 00 S.	147 50 E.	
N. point				2 30 S.	148 40 E.	
S. W. point				6 00 S.	146 37 E.	
Str. Dampier				6 15 S.	146 15 E.	
C. St. George				5 30 S.	150 55 E.	
I. St. John				4 20 S.	152 40 E.	
Buchanefs	Eu.	Scotland	Germ. Oce.	57 29 N.	1 23 W.	3 00
Buenos Ayres	Am.	Brazil	Atl. Ocean	34 35 S.	57 40 W.	
Burgaford point	Eu.	Iceland	N. Ocean	66 03 N.	16 34 W.	
Burlings, rocks	Eu.	Portugal	Atl. Ocean	39 30 N.	9 13 W.	
Burlington	Eu.	England	Germ. Oce.	54 00 N.	0 08 E.	
Button's Isles	Am.	New Brit.	Hudf. Str.	60 25 N.	65 00 W.	
C						
I. Cabrera	Eu.	Italy	Mediterran.	43 10 N.	9 11 E.	
Cadiz	Eu.	Spain	Atl. Ocean	36 33 N.	6 02 W.	4 30
Caen	Eu.	France	Eng. Chan.	49 11 N.	0 16 W.	9 00
Cagliari, I. Sardin.	Eu.	Italy	Med. Sea	39 25 N.	9 38 E.	
Calabar { Old	Af.	Guiney	Eth. Ocean	4 30 N.	8 10 E.	
New				5 00 N.	7 00 E.	
C. Calaberno	Af.	Natolia	Archipelago	38 42 N.	26 44 E.	
Calais	Eu.	France	Eng. Chan.	50 58 N.	01 56 E.	4 30
C. Calamadon	Af.	India	B. Bengal	10 22 N.	80 40 E.	

Caldera

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Caldera	Af.	I. Mindanao	S. Ocean	7° 00' N.	121° 25' E.	
I. Caldy	Eu.	England	St. Geo. Ch.	51° 33' N.	5° 14' W.	5h. 15m.
Calecut	Af.	India	Ind. Ocean	11° 15' N.	75° 39' E.	
Is. Caicos, or Cankrofs, N. part	Am.	Bahama I.	Atl. Ocean	21° 48' N.	71° 50' W.	
Cairo	Af.	Egypt	R. Nile	30° 02' N.	31° 31' E.	
I. Great Camanis	Am.	W. Indies	Atl. Ocean	19° 18' N.	80° 29' W.	
I. Little Camanis	Am.	W. Indies	Atl. Ocean	19° 42' N.	79° 20' W.	
Camboida	Af.	India	Ind. Ocean	10° 35' N.	104° 45' E.	
C. Cambron, or Carbon	Af.	Algiers	Med. Sea	37° 18' N.	4° 58' E.	
C. Cameron	Am.	NewSpain	Atl. Ocean	15° 35' N.	83° 29' W.	
R. Camerones	Af.	Guiney	Atl. Ocean	3° 30' N.	9° 10' E.	
B. Camerones	Am.	Magellan	Atl. Ocean	44° 50' S.	64° 10' W.	
Camfer, a sand	Eu.	DutchInd.	Germ. Oce.	53° 33' N.	5° 30' E.	1 30
Camin	Eu.	Germany	Baltic Sea	54° 04' N.	15° 40' E.	
Campeachy	Am.	Yucatan	Atl. Ocean	19° 36' N.	90° 53' W.	
I. Canaria	Af.	Canaries	Atl. Ocean	28° 07' N.	14° 26' W.	
C. Candenose	Eu.	Russia	N. Ocean	69° 25' N.	45° 30' E.	
Candia { C. St. John, W. end				35° 12' N.	23° 54' E.	
Candia { Candia	Eu.	Turkey	Medit. Sea	35° 19' N.	25° 23' E.	
I. { C. Salomon, East end				34° 57' N.	27° 06' E.	
Candia	Af.	I. Ceylon	Ind. Ocean	7° 54' N.	81° 53' E.	
I. Candu	Af.	India	Ind. Ocean	7° 30' S.	77° 55' E.	
C. Canso	Am.	Nov.Scot.	Atl. Ocean	45° 10' N.	59° 50' W.	
Canso Passage	Am.	Nov.Scot.	Atl. Ocean	45° 50' N.	60° 00' W.	
C. Cantin	Af.	Barbary	Atl. Ocean	32° 49' N.	9° 09' W.	0 00
Cantire, Mul	Eu.	Scotland	West. Ocean	55° 22' N.	5° 45' W.	
Canton	Af.	China	S. Ocean	23° 08' N.	113° 08' E.	
I. Capri	Eu.	Italy	Medit. Sea	40° 34' N.	14° 11' E.	
I. Capraya	Eu.	Italy	Medit. Sea	43° 03' N.	10° 15' E.	
C. Carapar	Af.	India	B. Bengal	19° 22' N.	86° 05' E.	
Caraccas	Am.	Ter.Firm.	Atl. Ocean	10° 06' N.	66° 45' W.	
Caries, or Ha- cluits Isles	Am.	GroenInd.	Baffing Bay	77° 15' N.	62° 00' W.	
Carinda Point	Am.	California	S. Ocean	38° 24' N.	124° 25' W.	
Carlisle	Eu.	England	Irish Sea	54° 47' N.	2° 35' W.	
C. Carmel	Af.	Syria	Levant	33° 08' N.	35° 35' E.	
Caroline Isles, { limits	Af.	Phil. Isles	South Sea	7° 10' N.	137° 25' E.	
				12° 00' N.	127° 25' E.	
C. Carthage	Af.	Barbary	Medit. Sea	36° 52' N.	10° 31' E.	
Carthagea	Am.	Ter. Fir.	Carib. Sea	10° 27' N.	75° 21' W.	
Carthagene	Eu.	Spain	Medit. Sea	37° 37' N.	1° 03' W.	8 1
Caskets	Eu.	I. Guerns.	Eng. Chan.	49° 50' N.	2° 26' W.	
C. Cassander	Eu.	Turkey	Archipelago	40° 02' N.	23° 41' W.	
I. St. Catherines	Am.	Brasil	Atl. Ocean	27° 45' N.	47° 58' W.	
Cat Isle { N. pt.	Am.	Bahama	Atl. Ocean	24° 50' N.	75° 38' W.	
				23° 48' N.	75° 35' W.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
				° /	° /	
Cathness Point, { or Dinnet Head	Eu.	Scotland	West. Ocean	58 46N.	3 17W	9h. 00m.
Catanea	Eu.	I. Sicily	Medit. Sea	42 40N.	20 30 E.	
C. Catocha	Am.	NewSpain	Carib. Sea	20 48N.	86 35W	
Cayenne	Am.	Ter.Firm.	Atl. Ocean	4 56N.	53 05W	
I. Celebes { N. E. point				1 48N.	124 37 E.	
{ N. point				1 40N.	120 50 E.	
{ W. point				3 00 S.	117 55 E.	
I. Celebes { S. W. point, Macasser	Af.	Spice Isles	Ind. Ocean	4 40 S.	119 05 E.	
{ S. point				5 40 S.	119 55 E.	
{ S. E. point				5 00 S.	121 40 E.	
I. Cephalonia	Eu.	Turkey	Medit. Sea	38 20N.	20 11 E.	
Ceuta	Af.	Barbary	Medit. Sea	35 45N.	4 42W	
I. Ceylon { Iafanapatam				9 47N.	80 55 E.	
{ N. part						
I. Ceylon { Trinquemale	Af.	India	Ind. Ocean	8 40N.	81 40 E.	
{ S. E. end				6 27N.	82 10 E.	
I. Ceylon { C. Gallo, S.				6 15N.	80 20 E.	
{ W. end				22 51N.	88 34 E.	
Chandenagar	Af.	Bengal	R. Ganges	33 22N.	79 50W	
Charles Town	Am.	Carolina	Ashley R.	37 11N.	76 07W	
C. Charles	Am.	Virginia	Atl. Ocean	62 20N.	74 30W	
C. Charles	Am.	N. Main	Hudf. Str.	51 50N.	51 10W	
C. Charles	Am.	New Brit	W. Ocean	52 30N.	82 00W	
I. Charlton	Am.	New Wls	Hudf. Bay	44 45N.	63 18W	
B. Chebueto	Am.	Nov.Scot.	Atl. Ocean	46 15N.	63 11W	
Cheignecto	Am.	Nov.Scot.	B. Fundy	49 38N.	01 33W	7 00
Cherbourg	Eu.	France	Engl. Chan.	74 35N.	18 05 E.	
Cherry Isle	Eu.	Greenlnd.	N. Ocean	53 10N.	2 25W	
Chester	Eu.	England	Irish Sea	50 47N.	3 00W	
Chiddock	Eu.	England	Engl. Chan.	60 22N.	65 00W	
C. Chidley	Am.	New Brit	Hudf. Str.	41 45 S.	73 05W	
I. Chiloe { N. pt.	Am.	Patagonia	S. Sea	43 50 S.	174 45W	
{ S. pt.				59 25N.	10 30 E.	
C. Chiokotkago	Af.	Siberia	N. Ocean	55 55N.	15 10 E.	
Christiana	Eu.	Norway	Sound	62 47N.	22 50 E.	
Christianople	Eu.	Sweden	Baltic Sea	17 15N.	62 50W	
Christianstadt	Eu.	Sweden	G. Bothnia	32 47 S.	30 00 E.	
I. St. Christoph's	Am.	Carib. I.	Atl. Ocean	66 30N.	171 10W	
R. St. Christoph's	Af.	Caffres	Ind. Ocean	59 03N.	95 35W	
C. Chukchenfe	Af.	Siberia	N. Ocean	30 00N.	121 50 E.	
R. Churchil	Am.	New Wls.	Hudf. Bay	42 10N.	12 01 E.	
I. Ghusan	Af.	China	Chinese Sea	51 18N.	9 50W	4 30
Civita Vecchia	Eu.	Italy	Medit. Sea	22 00 S.	95 40 E.	
C. Clear	Eu.	Ireland	West. Ocean	9 50N.	76 05 E.	
I. Cloate	Af.	India	Ind. Ocean	12 20 S.	98 10 E.	
Cochin	Af.	India	Ind. Ocean	5 00N.	88 45W	
I. Cocos	Af.	India	Ind. Ocean			
I. Cocos	Am.	Mexico	S. Ocean			

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
C. Cod	Am.	New Eng.	Atl. Ocean	42 15 N.	69 27 W.	
Colchester	Eu.	England	Germ. Oce.	52 00 N.	0 58 E.	
C. Cold	Eu.	Greenlnd.	N. Ocean	79 00 N.	10 00 E.	
R. Colorado	Am.	New Spain	G. Californ	31 40 N.	115 25 W.	
I. Colgau	Eu.	Russia	N. Ocean	69 20 N.	45 00 E.	
Collioure	Eu.	Spain	Medit. Sea	42 31 N.	3 10 E.	
C. Colone	Eu.	Turkey	Archipelago	37 43 N.	24 41 E.	
C. Colone	Af.	Natolia	Archipelago	39 10 N.	27 04 E.	
C. Colonna	Eu.	Italy	Medit. Sea	38 56 N.	18 05 E.	
Comana	Am.	Ter. Firm.	Atl. Ocean	10 00 N.	65 07 W.	
C. Comarin	Af.	India	Ind. Ocean	7 45 N.	78 17 E.	
C. Comfort	Am.	New Wls.	Hudf. Bay	64 45 N.	82 30 W.	
Concarneau	Eu.	France	B. Biscay	47 54 N.	3 50 W.	3h. oom.
C. Conception	Am.	Californ.	South Sea	35 40 N.	126 01 W.	
B. Conceptn. Ent	Am.	Newf Ind.	Atl. Ocean	48 25 N.	50 07 W.	
Conception	Am.	Chili	South Sea	36 43 S.	73 07 W.	
R. Congo	Af.	Congo	Eth. Ocean	5 45 S.	11 53 E.	
I. Coningen	Af.	New Zeld.	S. Ocean	34 30 S.	164 25 E.	
Coningsburg	Eu.	Poland	Baltic Sea	54 44 N.	21 53 E.	
Conquet	Eu.	France	Engl. Chan.	48 30 N.	4 35 W.	3 00
C. Conquibaco	Am.	Ter. Firm.	Atl. Ocean	12 15 N.	69 57 W.	
Constantinople	Eu.	Turkey	Archipelago	41 00 N.	28 58 E.	
Copenhagen	Eu.	Denmark	Baltic Sea	55 41 N.	12 50 E.	
Coperwic	Eu.	Norway	Sound	59 20 N.	10 10 E.	
I. Copland	Eu.	Ireland	Irish Sea	54 40 N.	6 40 W.	
I. Coquet	Eu.	England	Germ. Oce.	55 20 N.	1 25 W.	3 00
R. Coquimbo	Am.	Chili	S. Ocean	29 54 S.	71 10 W.	
C. Corbau	Af.	Natolia	Archipelago	38 03 N.	26 58 E.	
Cordoue	Eu.	France	B. Biscay	45 30 N.	01 10 W.	
Corea, South lim.	Af.	China	S. Ocean	34 50 N.	{ 124 25 E. 127 25 E.	
I. Corfu	Eu.	Turkey	Mediterran.	39 50 N.	19 48 E.	
C. Corientes	Af.	Cassers	Ind. Ocean	24 08 S.	36 49 E.	
C. Corientes	Am.	Mexico	S. Ocean	20 18 N.	108 00 W.	
Corinth	Eu.	Turkey	Archipelago	37 30 N.	23 00 E.	
Cork	Eu.	Ireland	St. Geo. Ch.	51 45 N.	7 30 W.	4 30
C. Corfe	Af.	Guiney	Eth. Sea	5 12 N.	0 23 W.	3 30
Corfica {	Eu.	Italy	Mediterran.	42 53 N.	9 40 E.	
				41 22 N.	9 26 E.	
I. Corvo	Eu.	Azores	Atl. Ocean	39 48 N.	31 22 W.	
I. Cosmoledo	Af.	Madagaf.	Ind. Ocean	10 28 S.	51 40 E.	
Cow and Calf	Eu.	Ireland	W. Ocean	51 22 N.	0 36 W.	
I. Cozumel	Am.	Jucatan	Atl. Ocean	19 36 N.	86 35 W.	
R. Crocei	Af.	China	B. Nankin	34 06 N.	120 10 E.	
Cromer	Eu.	England	Germ. Oce.	53 05 N.	0 56 E.	6 00
Crooked I. N. pt.	Am.	Bahama	Atl. Ocean	22 47 N.	73 50 W.	
Cross Isle	Eu.	Russia	White Sea	66 31 N.	36 33 E.	
Cross Point	Eu.	Nov. Zem	N. Ocean	72 00 N.	53 12 E.	
St. Cruz	Af.	Barbary	Atl. Ocean	30 36 N.	9 35 W.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
I. St. Cruz	Am.	Antilles I.	Atl. Ocean	17° 55' N.	65° 02' W.	
{ C. Antonio,				21° 45' N.	84° 05' W.	
W. pt.						
{ P. de Mais,				20° 03' N.	74° 52' W.	
E. pt.						
I. Cuba { Hollow Cape	Am.	Antilles I.	Atl. Ocean	19° 42' N.	77° 25' W.	
{ St. Jago				20° 03' N.	75° 51' W.	
{ St. Mary				21° 26' N.	78° 10' W.	
{ Le St. Lspirit				21° 56' N.	79° 50' W.	
{ Havana				23° 12' N.	81° 45' W.	
{ B. Hondy				22° 54' N.	82° 40' W.	
Cubbs Isles	Am.	New Wales	Hudf. Bay	54° 15' N.	82° 34' W.	
Cubello	Af.	Ind. Malab.	Ind. Ocean	7° 50' N.	71° 55' E.	
B. Cumberland	Am.	N. Main	Davis's Str.	66° 40' N.	65° 20' W.	
Curaffo	Am.	Ter Firm	Atl. Ocean	11° 56' N.	68° 20' W.	
I. Cuzzola	Eu.	Turkey	Med. Sea	42° 50' N.	16° 55' E.	
Cusco	Am.	Peru	Inland	12° 25' S.	73° 35' W.	
I. Cyprefs { C. Bassa, W.				35° 04' N.	33° 04' E.	
{ end						
{ C. St. Andr.				35° 40' N.	35° 08' E.	
E. end						
I. Cyprefs { C. de Gaffe,	Af.	Syria	Medit. Sea	34° 35' N.	33° 41' E.	
{ S. pt.						
{ C. Grego, S.				34° 57' N.	34° 36' E.	
E. pt.						
D						
Dabul	Af.	India	Arab. Sea	18° 24' N.	73° 33' E.	
Dahlak	Af.	Arabia	Red Sea	15° 50' N.	41° 44' E.	
I. Dageroort, {	Eu.	Livonia	Balt. Sea	58° 55' N.	22° 32' E.	
Light-house						
Dantzic	Eu.	Poland	Balt. Sea	54° 22' N.	18° 36' E.	
Str. Dardanel	Eu.	Turkey	Archipelago	40° 10' N.	26° 26' E.	
G. Darien	Am.	Ter Firm.	Carib. Sea	8° 45' N.	76° 35' W.	
Dartmouth	Eu.	England	Eng. Chan.	50° 27' N.	3° 36' W.	5h. 15m.
I. Dauphin	Am.	Louifiana	G. Mexico	29° 40' N.	87° 53' W.	
St. David's Head	Eu.	Wales	St. Geo. Ch.	51° 55' N.	5° 22' W.	6 00
Fort St. David's	Af.	India	Corom Coast	12° 05' N.	80° 55' E.	
I. Defeada	Am.	Carib. Is.	Atl. Ocean	16° 36' N.	61° 15' W.	
C. Defire	Eu.	No. Zem.	N. Ocean	77° 45' N.	79° 20' E.	
C. Defolation	Am.	Greenlnd.	N. Ocean	61° 45' N.	47° 00' W.	
Devil's Isles	Eu.	Greenlnd.	N. Ocean	80° 00' N.	11° 43' E.	
Dewpoint	Af.	India	B. Bengal	16° 07' N.	81° 47' E.	
I. Diego Royes	Af.	Ind. Malab.	Ind. Ocean	{ 0° 45' S.	70° 25' E.	
				{ 0° 30' N.		
I. Diego Garcia	Af.	India	Ind. Ocean	8° 45' S.	68° 10' E.	
Str. Diemen	Af.	Japan Is.	S. Ocean	31° 12' N.	130° 55' E.	
I. Dieu	Eu.	France	B. Biscay	46° 26' N.	2° 20' W.	
Diep	Eu.	France	Eng Chan.	49° 55' N.	1° 09' E.	9 45
Diggs's, or Dud-	Am.	Greenlnd.	Baffins Bay	76° 48' N.	59° 07' W.	
ley's Cape						

Po. Diu

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Po. Diu	Af.	India	Ind. Ocean	21° 37' N.	70° 28' E.	
C. Dobbs	Am.	North Wales	Hudf. Bay	65° 00' N.	81° 25' W.	
Dofare	Af.	Arabia	Ind. Ocean	16° 24' N.	53° 40' E.	
St. Dominga Hispaniola	Am.	Antilles	Atl. Ocean	18° 25' N.	69° 30' W.	
I. Dominico	Am.	Caribbe	Atl. Ocean	15° 15' N.	61° 08' W.	
Dorderecht	Eu.	Dutchlnd.	R. Maes	52° 00' N.	4° 26' E.	
C. Dorfui	Af.	Ajan	Ind. Ocean	10° 15' N.	50° 44' E.	
C. Doro	Eu.	Turkey	Archipelago	38° 02' N.	25° 12' E.	
Dort	Eu.	Dutchlnd.	Germ. Oce.	51° 47' N.	4° 40' E.	3h. oom.
I. Dofel	Eu.	Livonia	Balt. Sea	58° 20' N.	23° 00' E.	
Is. Dos Banhos	Af.	Zangueb.	Ind. Ocean	5° 15' N.	49° 24' E.	
Dover	Eu.	England	Eng. Chan.	51° 07' N.	1° 13' E.	0 00
Downs	Eu.	England	Germ. Oce.	51° 25' N.	1° 21' E.	2 15
Po. Dradate	Af.	Egypt	Red Sea	19° 56' N.	37° 40' E.	
Po. Drake, Sir Francis	Am.	California	S. Sea	38° 45' N.	128° 35' W.	
Dronthem	Eu.	Norway	N. Ocean	63° 16' N.	10° 55' E.	
Dublin	Eu.	Ireland	Irish Sea	53° 12' N.	6° 55' W.	8 15
Dunbar	Eu.	Scotland	Germ. Oce.	55° 58' N.	2° 22' W.	4 30
Dundalk	Eu.	Ireland	Irish Sea	53° 57' N.	6° 28' W.	
Dundee	Eu.	Scotland	Germ. Oce.	56° 26' N.	2° 48' W.	2 15
Dungarvan	Eu.	Ireland	Atl. Ocean	51° 57' N.	7° 55' W.	4 30
Dungeness	Eu.	England	Engl. Chan.	51° 00' N.	0° 51' E.	9 45
Dungsbay Head	Eu.	Scotland	Germ. Oce.	58° 45' N.	2° 57' W.	
Dunkirk	Eu.	France	Germ. Oce.	51° 02' N.	2° 27' E.	0 00
Dunnose	Eu.	I. Wight	Eng. Chan.	50° 38' N.	1° 23' W.	9 45
Durazzo	Eu.	Turkey	Mediterr. Sea	41° 58' N.	25° 00' E.	
E						
Edinburgh	Eu.	Scotland	Germ. Oce.	55° 58' N.	3° 00' W.	4 30
Edystone	Eu.	England	Engl. Chan.	50° 12' N.	4° 20' W.	7 30
I. Elba	Eu.	Italy	Mediterran.	42° 52' N.	10° 38' E.	
R. Elbe mouth	Eu.	Germany	Germ. Oce.	54° 18' N.	7° 10' E.	0 00
Elbing	Eu.	Poland	Balt. Sea	54° 12' N.	20° 35' E.	
Elfingburg	Eu.	Sweden	Balt. Sea	56° 00' N.	13° 35' E.	
Elfinore	Eu.	Denmark	Balt. Sea	56° 00' N.	13° 23' E.	
I. Eluthe- ria	N. pt. S. pt.	Am. Bahama	Atl. Ocean	25° 45' N. 24° 57' N.	76° 42' W. 75° 53' W.	
Embden	Eu.	Germany	Germ. Oce.	53° 05' N.	7° 26' E.	0 00
R. Emes mouth	Eu.	Germany	Germ. Oce.	53° 10' N.	7° 20' E.	7 30
Enchuyfen	Eu.	Dutchlnd.	Zuyder Sea	52° 43' N.	5° 06' E.	0 00
I. Engano, or Trompeuse	Af.	Siam	Ind. Ocean	6° 00' S.	102° 35' E.	
B. Enhorn	Eu.	Greenlnd.	N. Sea	78° 45' N.	26° 05' E.	
Ephesus	Af.	Natolia	Archipelago	38° 00' N.	27° 53' E.	
Estaples	Eu.	France	Engl. Chan.	50° 34' N.	1° 42' E.	11 00
I. Exuma	Am.	Bahama	Atl. Ocean	23° 25' N.	75° 35' W.	

Names of Places.	Con	Countries.	Coast.	Latitude.	Longitud.	H. Water.	
F				• /	° /		
Fairhead	Eu.	Ireland	W. Ocean	55 19N.	6 20W		
C. Falcon	Af.	Barbary	Medit. Sea	36 03N.	0 14W		
I. Falk-land	E. end Isl. A nifant	Am.	Patagon	Atl. Ocean	51 30 S.	55 40W	
					52 15 S.	56 47W	
Falmouth	Eu.	England	Eng. Chan.	50 12N.	5 12W	4h. 30m.	
C. Falo	Eu.	Turkey	Archipelago	40 12N.	24 27 E.		
C. Falso	Af.	Zangueb.	Ind. Ocean	8 52 S.	39 55 E.		
Falsterbom	Eu.	Sweden	Balt. Sea	55 20N.	13 36 E.		
I. Fana	Eu.	Turkey	Medit. Sea	40 14N.	19 32 E.		
R. Farate	Af.	Egypt	Red Sea	21 40N.	36 29 E.		
Faro Head, or C. Wrath	Eu.	Scotland	W. Ocean	58 44N.	4 50 W		
C. Farewell	Am.	Greenlnd.	N. Ocean	59 37N.	44 30W		
C. Fartack	Af.	Arabia	Ind. Ocean	15 41N.	51 31 E.		
C. Fear	Am.	Carolina	Atl. Ocean	34 04N.	78 09W		
I. Fernando Noranha	Am.	Brafil	Atl. Ocean	3 50 S.	30 35W		
I. Felicur, Li- pari Isles						Eu.	Italy
I. Fermina	Eu.	Turkey	Archipelago	37 24N.	25 05 E.		
I. Fernandepo	Af.	Guiney	Atl. Ocean	3 02N.	3 33 E.		
I. Ferro	Af.	Canaries	Atl. Ocean	27 48N.	17 26W		
C. Finisterre	Eu.	Spain	Atl. Ocean	43 15N.	9 20W		
I. Fironda	Af.	Corea	South Sea	33 30N.	127 25 E.		
Flamborough Head	Eu.	England	Germ. Ocean	54 08N.	0 11 E.	3 00	
I. Flores	Eu.	Azores	Atl. Ocean	39 23N.	30 22W		
C. Florida	Am.	Florida	G. Mexico	25 50N.	80 20 W	7 30	
Flushing	Eu.	Dutchlnd.	Germ. Ocean	51 33N.	3 20 E.	0 45	
I. Fly	Eu.	Dutchlnd.	Germ. Ocean	53 16N.	5 35 E.	7 30	
Forbisher's Straits	Am.	Groenlnd.	Atl. Ocean	62 05N.	47 18W		
N. Foreland	Eu.	England	Germ. Oce.	51 28N.	1 10 E.	9 45	
S. Foreland	Eu.	England	Eng. Chan.	51 12N.	1 18 E.	9 45	
Foreland Fair	Eu.	Ireland	N. Ocean	55 05N.	6 30W		
Foreland Fair	Eu.	Greenlnd.	N. Ocean	79 18N.	10 50 E.		
Foreland Merchts.	Am.	Greenlnd.	N. Ocean	63 20N.	17 05W		
I. Formentaria	Eu.	Spain	Medit. Sea	38 33N.	1 15 E.		
I. Formigo	Eu.	Azores	Atl. Ocean	37 55N.	21 50W		
C. Formosa	Af.	Guiney	Eth. Sea	4 22N.	5 43 E.		
R. Formosa	Af.	Guiney	Eth. Sea	6 10N.	4 49 E.		
I. For- mosa	N. pt. S. pt.	Af.	China	Ind. Ocean	25 25N.	121 25 E.	
					22 00N.	120 40 E.	
I. Forteventura, S. W. end	Af.	Canaries	Atl. Ocean	28 22N.	13 25W		
Foulness	Eu.	England	Germ. Oce.	52 57N.	0 58 E.	6 45	
Foulfound	Eu.	Greenlnd.	N. Ocean	77 30N.	12 50 E.		
Foye	Eu.	England	Eng. Chan.	50 25N.	4 30W	5 15	
C. St. Francis	Am.	Peru	S. Sea	0 30N.	80 35W		
I. St. Francisco	Af.	Zanguebar	nd. Ocean	6 23 S.	53 22 E.		
R. St. Francisco	Am.	Brafil	Atl. Ocean	10 55 S.	36 30W		

Freder

Names of places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Frederickstadt	Eu.	Norway	Sound	59 00N.	11 10 E.	
R. French Keys	Am.	Bahama	Atl. Ocean	22 30N.	73 40W	
Fretum Borough	Eu.	Russia	N. Ocean	70 00N.	61 20 E.	
C. Frio	Am.	Brazil	Atl. Ocean	23 00 S.	40 11W	
R. Fugor	Af.	Zangueb.	Ind. Ocean	00 10N.	42 05 E.	
I. Fuego	Af.	De Verd	Atl. Ocean	14 55N.	23 28W	
B. Fushan	Af.	China	S. Sea	23 00N.	112 35 E.	
I. Fyal	Eu.	Azores	Atl. Ocean	38 38N.	27 05W	
G						
I. Galla	Am.	Terra Fir.	S. Sea	2 40N.	79 35W	
R. Gallega	Am.	Patagon	Atl. Ocean	51 37 S.	65 35W	
I. Gallego	Am.	Ter. Fir.	S. Sea	1 40N.	104 35W	
Gallipoli	Eu.	Italy	Medit. Sea	40 19N.	18 08 E.	
Gallipoly	Eu.	Turkey	Archipelago	40 36N.	27 02 E.	
I. Gallita	Af.	Barbary	Medit. Sea	37 42N.	9 03 E.	
C. Gallo	Af.	I. Ceylon	Ind. Ocean	6 15N.	80 20 E.	
Is. Gallopega	Am.	Peru	South Sea	{ 2 00N. 2 00 S.	89 00W	
Gally Head	Eu.	Ireland	W. Ocean	52 40N.	9 30W	
Galway	Eu.	Ireland	W. Ocean	53 10N.	10 03W	
R. Gambia	Af.	Negrold.	Atl. Ocean	13 00N.	14 58W	
I. Gamo	Af.	India	Ind. Ocean	3 05 S.	77 25 E.	
C. Gardafuy	Af.	Anian	Ind. Ocean	11 48N.	50 25 E.	
R. Garonne	Eu.	France	B. Biscay	45 30N.	1 05W	3h. oom.
C. de Gatt	Eu.	Spain	Medit. Sea	36 32N.	2 05W	
C. Gear	Af.	Barbary	Atl. Ocean	30 35N.	10 01W	
Genoa	Eu.	Italy	Medit. Sea	44 25N.	8 41 E.	
B. St. George	Am.	Newf land	Atl. Ocean	48 19N.	56 00W	
I. St. George	Af.	Natolia	Archipelago	38 47N.	25 07 E.	
I. St. George	Eu.	Azores	Atl. Ocean	38 45N.	25 55W	
St. George's Fort	Af.	India	Bengal B.	13 15N.	80 50 E.	
Gibraltar	Eu.	Spain	Medit. Sea	36 13N.	4 53W	o o
I. Gilolo {	N. pt. S. pt.	Af. Spice Is.	Ind. Ocean	{ 2 30N. 1 30 S.	128 00 E. 29 25 E.	
Glasgow	Eu.	Scotland	R. Clyd	55 52N.	4 05W	
Goa	Af.	India	Arab. Sea	15 31N.	73 50 E.	
Goes	Eu.	Dutchld.	Germ. Oce	51 39N.	4 05 E.	
Golfe triste	Am.	Ter. Fir.	Carib. Sea	10 20N.	67 40W	
Gombroon	Af.	Perfia	Perf. Gulf	27 40N.	55 20 E.	
I. Gomero	Af.	Canaries	Atl. Ocean	28 08N.	16 35W	
C. Gondewar	Af.	India	B. Bengal	16 55N.	82 55 E.	
C. Good Hope	Af.	Caffers	Ind. Ocean	34 15 S.	20 07 E.	3 o
I. Gorea	Af.	Negrold.	Atl. Ocean	14 40N.	17 00W	
I. Gorgona	Eu.	Italy	Medit. Sea	43 21N.	9 11 E.	
I. Goth. land {	N. end S. end Wisby	Eu. Sweden	Balt. Sea	58 00N. 56 58N. 57 40N.	20 15 E. 19 37 E. 19 50 E.	
I. Goto	Af.	Corea	South Sea	34 25N.	125 50 E.	
Gottenberg	Eu.	Sweden	Sound	57 45N.	12 15 E.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
R. Grand	Am.	Paraguay	Atl. Ocean	31 58 S.	50 35 W	
Granville	Eu.	France	Eng. Chan.	48 50 N.	1 32 W	7h. 00m.
I. Gratiofa	Af.	Canaries	Atl. Ocean	29 37 N.	12 08 W	
I. Gratiofa	Eu.	Azores	Atl. Ocean	39 06 N.	26 10 W	
C. Gratiofa a dios	Am.	NewSpain	Carib. Sea	14 48 N.	82 15 W	
Graveline	Eu.	France	Eng. Chan.	50 59 N.	2 13 E.	0 00
Gravesend	Eu.	England	R. Thames	51 35 N.	0 20 E.	1 30
I. Grenada	Am.	Caribbe	Atl. Ocean	11 52 N.	61 39 W	
Greenwich	Eu.	England	R. Thames	51 28 N.	0 05 E.	
C. Gremia	Eu.	Turkey	Archipelago	40 33 N.	26 20 E.	
Gripfswald	Eu.	Germany	Bal. Sea	54 14 N.	15 34 E.	
Grimesby	Eu.	England	Germ. Oce.	53 30 N.	0 56 E.	
Groin, or C. } Corunna }	Eu.	Spain	B. Biscay	43 28 N.	9 20 W	3 00
I. Groy	Am.	Newfland	Atl. Ocean	50 39 N.	51 35 W	
I. Guardaloupe	Am.	Caribbe	Atl. Ocean	16 20 N.	61 25 W	
Guayaquil	Am.	Peru	S. Sea	2 10 S.	80 10 W	
I. Guernsey	Eu.	England	Eng. Chan.	49 30 N.	2 47 W	0 45
Gulf	Eu.	England	St. Geo. Ch.	50 06 N.	6 00 W	
H						
Haeluit's Headland	Eu.	Greenlnd.	N. Ocean	79 55 N.	12 00 E.	
I. Hai- { N.E. pt. nam { S.W. pt.	Af.	China	Ind. Ocean	{ 19 45 N. 18 22 N.	{ 110 13 E. 108 13 E.	
I. Hall	Am.	Groenlnd.	Atl. Ocean	63 56 N.	44 26 W	
Halliford	Eu.	Iceland	N. Ocean	64 30 N.	27 15 W	
Hambourgh	Eu.	Germany	R. Elbe	53 41 N.	10 38 E.	6 00
Harlem	Eu.	Dutchlnd.	Germ. Oce.	52 24 N.	4 10 E.	9 00
Hartland Point	Eu.	England	Bristol Ch.	51 06 N.	4 35 W	
Hartlepool	Eu.	England	Germ. Oce.	54 40 N.	0 56 W	3 00
Harwich	Eu.	England	Germ. Oce.	52 11 N.	1 18 E.	11 15
C. Hatteras	Am.	Carolina	Atl. Ocean	35 24 N.	76 20 W	
Havannah	Am.	I. Cuba	Atl. Ocean	23 12 N.	81 11 W	
Havre de Grace	Eu.	France	Eng. Chan.	49 30 N.	0 17 E.	9 00
I. St. Helena	Af.	Caffers	Atl. Ocean	16 00 S.	5 53 W	
Helie's Sound	Eu.	Greenlnd.	N. Ocean	79 15 N.	12 50 E	
Is. Heligh Land	Eu.	Norway	N. Ocean	65 15 N.	9 30 E.	
C. Henrietta	Am.	New Wales	Hud. Bay	55 08 N.	84 25 W	
C. Henry	Am.	Virginia	Atl. Ocean	36 57 N.	76 23 W	
I. Heys	Eu.	France	B. Biscay	46 24 N.	2 14 W	
High Mount	Eu.	Greenlnd.	N. Ocean	83 23 N.	26 40 E	
C. Hinlopen	Am.	Maryland	Atl. Ocean	39 10 N.	74 50 W	
M. H paniola {				18 17 N	74 30 W	
				19 50 N.	73 08 W	
				18 28 N.	72 42 W	
				18 25 N.	69 30 W	
				19 05 N.	68 30 W	

R. Hogsties

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
R. Hogsties	Am.	Bahama	Atl. Ocean	21 41 N.	73 15 W	
New Holland { B. Seadogs				25 33 S.	108 10 E.	
{ N.W. limit	Af.		Ind. Ocean	20 30 S.	112 15 E.	
{ S.W. limit				34 45 S.	113 00 E.	
Holy Cape	Af.	Siberia	N. Ocean	72 32 N.	179 45 E.	
Holy Head	Eu.	Wales	Irish Sea	53 23 N.	4 40 W	
C. Honduras	Am.	New Spain	Carib. Sea	16 18 N.	85 23 W	
B. Hondy, I. Cuba	Am.	Antilles	Atl. Ocean	22 54 N.	82 40 W	
Honfleur	Eu.	France	R. Seine	49 24 N.	0 20 E.	
Hope Isle	Eu.	Greenlnd.	N. Ocean	76 22 N.	23 40 E.	
C. Horn	Am.	Ter. Fuego	S. Ocean	55 42 S.	66 00 W	
Hornsound	Eu.	Greenlnd.	N. Ocean	76 41 N.	13 36 E.	
La Hougue	Eu.	France	Engl. Chan.	49 45 N.	1 55 W	
R. Hughley	Af.	India	B. Bengal	21 45 N.	89 15 E.	
Hull	Eu.	England	R. Humber	53 50 N.	0 28 W	6h. 00m.
R. Humber, Ent.	Eu.	England	Germ. Oce.	53 55 N.	0 24 E.	4 30
I. Hyneago	Am.	Bahama	Atl. Ocean	21 07 N.	73 01 W	
I						
Jado	Af.	Japon	S. Sea	36 00 N.	139 40 E.	
C. Jaffanapatan	Af.	I. Ceylon	Ind. Ocean	9 47 N.	80 55 E.	
I. Jago	Af.	C. Verd	Atl. Ocean	15 07 N.	22 35 W	
I. Jamaic. { West end				18 45 N.	78 00 W	
{ Port Royal	Am.	W. Indies	Atl. Ocean	17 40 N.	75 52 W	
{ East end				17 58 N.	76 05 W	
James Town	Am.	Virginia	B. Chesapeake	37 30 N.	76 00 W	
R. Janeiro	Am.	Brazil	Atl. Ocean	23 00 S.	41 08 W	
Japan Isles	Af.		S. Sea	40 40 N.	141 25 E.	
				31 45 N.	126 10 E.	
Java I. { C. Delo, W.				6 50 S.	105 15 E.	
{ pt.	Af.	Siam	Ind. Ocean	7 00 S.	115 55 E.	
{ East limit				8 30 S.		
Ice Point	Eu.	Nov. Zem	N. Ocean	77 40 N.	69 10 E.	
Ice Sound	Eu.	Greenlnd.	N. Ocean	78 13 N.	12 00 E.	
I. Jersey	Eu.	England	Engl. Chan.	49 07 N.	2 26 W	
Jerusalem	Af.	Palestine	Inland	31 50 N.	35 25 E.	
I. Illay, S. pt.	Eu.	Scotland	West. Ocean	55 39 N.	6 20 W	
R. Indus	Af.	India	Ind. Ocean	25 50 N.	66 33 E.	
Inverness	Eu.	Scotland	Germ. Oce.	57 33 N.	4 02 W	
I. Joanna	Af.	Zangueb.	Ind. Ocean	12 05 S.	45 45 E.	
Joddah	Af.	Arabia	Red Sea	22 00 N.	39 27 E.	
C. St. John	Am.	Newfland	W. Ocean	50 25 N.	52 45 W	
C. St. John	Af.	Maiumbo	Eth. Ocean	1 17 N.	9 34 E.	
Fort St. Johns	Am.	Newfland	Atl. Ocean	48 04 N.	50 05 W	
I. St. John { E. pt.	Am.	Canada	B. St. Lau-	46 36 N.	60 00 W	
{ W. pt.			rence	47 35 N.	62 05 W	
I. St. John de Nova	Af.	Madagaf.	Ind. Ocean	17 00 S.	44 02 E.	
St. John de Luz	Eu.	France	B. Biscay	43 10 N.	1 38 W	3 30
Cape Jones	Am.	New Brit.	Hudf. Bay	55 15 N.	79 00 W	
Joppa	Af.	Syria	Levant	32 45 N.	36 00 E.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Jones's Sound	Am.	Groenlnd.	Baffin's Bay	71 07N.	91 30W	
Ipswich	Eu.	England	Germ. Oce.	52 14N.	1 00 E.	
Isfahan	Af.	Perfia	R. Zenderu	32 25N.	52 55 E.	
I. Juan fernandes	Am.	Chili	S. Sea	34 10 S.	79 35W	
Por. St. Julian	Am.	Patagonia	S. Atl. Ocean	48 51 S.	65 10W	
I. Ivica	Eu.	Spain	Medit. Sea	38 54N	1 15 E.	
K						
Kalmer	Eu.	Sweden	Baltic Sea	56 40N.	17 25 E.	
Kambaya	Af.	India	Ind. Ocean	23 36N.	72 50 E.	
Kam- chatka { Lower	Af.	Siberia	South Sea	56 11N.	159 25 E.	
chatka { Upper				54 48N.	157 25 E.	
I. Karaghinskoy	Af.	Siberia	S. Sea	58 00N.	162 10W	
I. St. Katherines	Am.	Brasil	Atl. Ocean	27 45 S.	47 58W	
Keco	Af.	Tonquin	Ind. Ocean	21 55N.	106 10 E.	
Kegor	Eu.	Moscovy	N. Ocean	70 18N.	34 00 E.	
R. Kennebeck	Am.	New Eng.	Atl. Ocean	44 00N.	69 45W	
Kentish knock, { a sand }	Eu.	England	Germ. Oce.	51 42N.	1 45 E.	oh. oom.
I. St. Kilda	Eu.	Scotland	W. Ocean	57 44N	8 18W	
I. Kilduin	Eu.	Lapland	N. Ocean	69 30N	31 20 E.	7 30
Kinfale	Eu.	Ireland	Atl. Ocean	51 32N.	1 20W	4 30
Klip	Eu.	Greenlnd.	N. Ocean	80 10N.	12 22 E.	
R. Kola	Eu.	Lapland	N. Ocean	69 20N.	35 30 E.	
C. Kol	Eu.	Sweden	Sound	56 50N.	13 13 E.	
Port Komol	Af.	Abyffinia	Red Sea	22 30N.	36 17 E.	
Komero Isles	Af.	Zangueb.	Ind. Ocean	10 48 S.	44 46 E.	
R. Kowimia	Af.	Siberia	N. Ocean	13 10 S.	46 22 E.	
				70 40N	159 00 E.	
L						
Ladrone, or { Marian Isles }	Af.		S. Ocean	21 00N.	144 00 E.	
				13 15N.	142 55 E.	
C. Lagulias	Af.	Cafraria	Ind. Ocean	34 45 S.	21 40 E.	
Lancaster	Eu.	England	St. Geo. Ch.	54 42N	4 36W	
I. Lancerota	Af.	Canaries	Atl. Ocean	29 30N	12 20W	
Land's End	Eu.	England	St. Geo. Ch.	50 06N.	6 00W	7 30
Langeness	Eu.	Nov Zem	N. Ocean	74 40N	53 36 E.	
I. Lambay	Eu.	Ireland	Irish Sea	53 24N.	7 30W	8 15
I. Lampadosa	Af.	Tunis	Medit. Sea	35 32N.	12 45 E.	
B. St. Lazarus	Am.	Patagon	S. Sea	48 42 S.	73 35W	
C. Ledo	Af.	Angola	Atl. Ocean	9 24 S.	12 55 E.	
Leith	Eu.	Scotland	Germ. Oce.	55 58N	2 59W	4 30
Leghorn	Eu.	Italy	Medit. Sea	43 33N.	10 25 E.	
I. Lemnos	Af.	Natolia	Archipelago	40 02N.	25 36 E.	
C. Lengua	Eu.	Turkey	Medit. Sea	40 44N.	19 36 E.	
Leostaff	Eu.	England	Germ. Oce.	52 38N.	1 54 E.	9 45
Lepanto	Eu.	Turkey	Medit. Sea	38 20N.	22 03 E.	
ow	Eu.	Denmark	Sound	57 05N	11 06 E.	

Liverpool

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Liverpool	Eu.	England	Irish Sea	53 22N.	2 30W	
I. Lewes, N. pt.	Eu.	Scotland	West. Ocean	58 35N.	6 37W	
Liampo, or Ningpo	Af.	China	South Sea	30 00N.	120 30E	
Lima	Am.	Peru	South Sea	12 20 S.	77 35W	
Lime	Eu.	England	Eng. Chan.	50 45N.	3 15W	
Limerick	Eu.	Ireland	R. Shannon	52 22N.	9 48W	
I. Limosa	Eu.	Italy	Med. Sea	36 08N.	13 01 E.	
I. Lipari	Eu.	Italy	Medit. Sea	38 35N.	15 31 E.	
I. Liqueo	Af.	Japan	South Sea	28 00N.	127 30 E.	
Lisbon	Eu.	Portugal	R. Tagus	38 42N.	8 52W	2h. 15m.
Lisbon Rock	Eu.	Portugal	W. Ocean	38 42N.	9 25W	
I. Lissa	Eu.	Dalmatia	Adriat. Sea	42 56N.	18 32 E.	
Lizard	Eu.	England	Engl. Chan.	49 57N.	5 14W	7 30
Is. Loffout	S.W. end N.E. end	Eu. Norway	N. Ocean	68 15N.	10 20 E.	
				69 00N.	12 00 E.	
R. Loire, Ent.	Eu.	France	B. Biscay	47 07N.	2 05W	3 00
London	Eu.	England	R. Thames	51 32N.	0 00	3 00
New London	Am.	New Eng.	W. Ocean	41 50N.	72 14W	
Londonderry	Eu.	Ireland	West. Ocean	55 01N.	7 31W	
Long Isle	Am.	New Eng.	W. Ocean	41 00N.	71 59W 74 20W	
I. Longo	Eu.	Dalmatia	Adriat. Sea	43 45N.	17 58 E.	
Longsand Head	Eu.	England	Germ. Oce.	51 47N.	1 41 E.	
Lookout Point	Eu.	Greenlnd.	N. Ocean	76 40N.	16 25 E.	
C. Lopas	Af.	Loango	Atl. Ocean	0 47 S.	8 30 E.	
B. St. Louis	Am.	Louisiana	G. Mexico	28 50N.	97 08W	
Louisbourg	Am.	C. Breton	B. St. Lawr.	46 50N.	61 30W	
Lubec	Eu.	Germany	Balt. Sea	54 00N.	11 40 E.	
C. St. Lucas	Am.	California	South Sea	23 15N.	111 35W	
R. Lucia	Af.	Caffers	Ind. Ocean	27 52 S.	33 28 E.	
I. St. Lucia	Af.	C. de Verd	Atl. Ocean	17 25N.	24 05W	
I. St. Lucia	Am.	Caribbe	Atl. Ocean	13 45N.	61 00W	
I. Luconia	N. E. point C. Bajador Manila S. W. point E. point	Af. Phil. Is.	South Sea	19 25N.	121 45 E.	
				18 50N.	120 25 E.	
				14 30N.	120 30 E.	
				13 30N.	119 35 E.	
Lunden	Eu.	Sweden	Baltic Sea	55 42N.	13 25 E.	
I. Lundy	Eu.	England	St. Geo. Ch.	51 20N.	4 04W	5 15
Lupis's Head	Eu.	Ireland	W. Ocean	52 24N.	10 15W	
Lynn	Eu.	England	Germ. Oce.	52 55N.	0 32 E.	6 00
M						
C. Mabo	Af.	New Guinea	S. Ocean	0 40 S.	130 05 E.	
Macao, or Makau	Af.	China	S. Sea	22 13N.	113 51 E.	
Macassar	Af.	I. Celebes	S. Sea	4 40 S.	119 05 E.	
C. Machian	Eu.	Spain	B. Biscay	43 44N.	3 05W	

Names of Places	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
				° /	° /	
I. Madagascar { C. St. Mary, S. pt.				25 24 S	45 53 E.	
B. St. Augustine				23 15 S.	44 25 E.	
Terra de Gada				19 36 S.	44 46 E.	
C. St. Andrew				15 46 S.	45 22 E.	
C. St. Sebastian	Af.		Ind. Ocean	12 30 S.	49 13 E.	
C. de Ambre, N. pt				12 15 S.	50 15 E.	
B. d'Antongil				16 00 S.	49 40 E.	
Antavare				20 53 S.	47 48 E.	
Po. Dauphin				24 48 S.	48 06 E.	
I. Madeira { Funchal	Af.	Canaries	Atl. Ocean	32 38 N.	16 51 W	
deira { W. end				32 25 N.	17 21 W	
Madrid	Eu.	Spain	R. Manzanares	40 25 N.	03 39 W	
Madura	Af.	India	Ind. Ocean	10 15 N.	78 35 E.	
R. Maes, mouth	Eu.	Dutch Ind.	Germ. Oce.	52 06 N.	3 50 E.	oh. 45 m.
Str. Le Maire	Am.	Patagonia	Atl. Ocean	55 00 S.	62 10 W	
Magadoxa	Af.	Zangueb.	Ind. Ocean	2 53 N.	45 25 E.	
Str. Magellan { E. ent.	Am.	Patagonia	Atl. Ocean	52 50 S.	72 35 W	
{ W. ent			S. Sea	52 36 S.	62 35 W	
Magisilan	Af.	India	Malab. Coa.	13 10 N.	74 14 E.	
I. Maguana	Am.	Bahama I.	Atl. Ocean	22 36 N.	72 25 W	
P. Mahon, Isl. {	Eu.	Spain	Medit. Sea	39 45 N.	4 19 E.	
Minorca {						
Majorca, Isl. {	Eu.	Spain	Medit. Sea	39 45 N.	2 25 E.	
Majorca {						
C. Mala	Eu.	Turkey	Archipelago	37 20 N.	24 07 E.	
Malacca	Af.	India	Str. Malacca	2 12 N.	102 10 E.	
Malaga	Eu.	Spain	Medit. Sea	36 43 N.	4 02 W	
Is. Maldiva { N. end	Af.	India	Ind. Ocean	7 20 N.	73 03 E.	
{ S. end				0 20 S.	76 10 E.	
Malestrom						
Whirlpool {	Eu.	Norway	W. Ocean	68 08 N.	10 40 E.	
I. Malique	Af.	Maldiva I.	Ind. Ocean	7 45 N.	72 40 E.	
St. Maloes	Eu.	France	Eng. Chan.	48 39 N.	2 05 W	6 00
I. Malta	Eu.	Italy	Medit. Sea	35 54 N.	14 34 E.	
I. Man, W. end	Eu.	England	Irish Sea	53 45 N.	5 00 W	9 00
Mangalor	Af.	India	Ind. Ocean	13 02 N.	75 10 E.	
Str. Manila	Af.	I. Luconia	South Sea	14 35 N.	124 00 E.	
I. Mansfield, N. pt.	Am.	New Brit.	Hud. Bay	62 27 N.	80 30 W	
I. Manfia	Af.	Zangueb.	Ind. Ocean	8 36 S.	40 40 E.	
I. Mardou	Eu.	Norway	Sound	58 14 N.	8 55 E.	
I. Margarita	Am.	Terra Fir.	Atl. Ocean	11 15 N.	63 35 W	
R. Maragnon	Am.	Brazil	Atl. Ocean	1 48 S.	44 17 W	
Margate	Eu.	England	Eng. Chan.	51 29 N.	1 10 E.	11 15
C. St. Maria	Eu.	Portugal	Atl. Ocean	36 45 N.	7 45 W	
C. St. Maria, or Lucia	Eu.	Italy	Medit. Sea	40 04 N.	18 31 E.	
Marian, { N. lim.						
or Ladrone {	Af.		S. Ocean	21 00 N.	144 00 E.	
Iles { S. lim.						
I. St. Maries	Eu.	Azores	Atl. Ocean	37 00 N.	22 56 W	

St. Maries

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
St. Maries	Eu.	I. Scilly	Eng. Chan.	49 57N.	6 45W	
I. Marigallante	Am.	W. Indies	Atl. Ocean	16 00N.	61 10W	
I. Maritimo, } Sicily	Eu.	Italy	Medit. Sea	38 04N.	12 33 E.	
C. Martelo	Eu.	Turkey	Med. Sea	38 00N.	26 00 E.	
St. Martha	Am.	Ter.Firm.	Atl. Ocean	11 20N.	73 40W	
I. St. Martin	Am.	W. Indies	Atl. Ocean	18 06N.	62 30W	
C. St. Martin	Af.	Caffers	Atl. Ocean	32 08 S.	18 58 E.	
C. St. Martin	Eu.	Spain	Medit. Sea	38 44N.	0 25 E.	
I. Martinique, } Fo. Royal	Am.	W. Indies	Atl. Ocean	14 33N.	60 54W	
Marfeilles	Eu.	France	Medit. Sea	43 18N.	5 27 E.	
C. St. Mary	Am.	Newfland	Atl. Ocean	46 52N.	52 15W	
C. St. Mary	Am.	Brafil	Atl. Ocean	34 52 S.	52 55W	
C. St. Mary	Af.	Natolia	Archipelago	37 46N.	27 21 E.	
C. St. Mary	Eu.	Spain	N. Atl. Oce.	36 46N.	7 49W	
C. Virgin Mary	Am.	Patagonia	S. Atl. Oce.	52 21 S.	67 29W	
I Mascarenhas	Af.	Zangueb.	Ind. Ocean	3 30 S.	57 25 E.	
I. Mascarin	Am.	Peru	S. Ocean	1 20 S.	88 50W	
Mascat	Af.	Arabia	Ind. Ocean	23 10N.	57 40 E.	
Masterland	Eu.	Sweden	Sound	57 58N.	12 00 E.	
Masulipatan	Af.	India	B. Bengal	16 28N.	81 40 E.	
C. Matapan	Eu.	Turkey	Archipelago	36 25N.	22 40 E.	
I. Matbare	Af.	Japan	S. Ocean	26 30N.	137 00 E.	
I. St. Mathews	Af.	Guinea	Eth. Ocean	1 23 S.	6 11W	
I. Mauritius	Af.	Madagaf.	Ind. Ocean	20 15 S.	58 10 E.	
I. May	Af.	CapeVerd	Atl. Ocean	15 19N.	21 53W	
C. May	Am.	Penfilvan.	Atl. Ocean	39 15N.	74 43W	
I. Mayetta	Af.	Madagaf.	Ind. Ocean	12 53 S.	46 10 E.	
Mecca	Af.	Arabia	Red Sea	21 40N.	41 00 E.	
Medina	Af.	Arabia	Red Sea	24 58N.	39 53 E.	
I. Melada	Eu.	Dalmatia	Adriat. Sea	42 40N.	19 34 E.	
Melinde	Af.	Zangueb.	Ind. Ocean	3 07 S.	39 40 E.	
I. Melo	Eu.	Turkey	Archipelago	36 41N.	25 05 E.	
Memel	Eu.	Courland	Balt. Sea	55 48N.	22 23 E.	
Memiffan	Eu.	France	B. Biscay	44 20N.	1 23W	3h. 30m.
I. Menado	Af.	I. Celebes	S. Sea	1 36N.	122 25 E.	
C. Mendozin	Am.	California	S. Sea	41 20N.	130 15W	
R. Meraparovous	Am.	Bahama	Atl. Ocean	21 58N.	74 13W	
Messina	Eu.	I. Sicily	Medit. Sea	38 21N.	16 21 E.	
C. Mesurato	Af.	Tripoli	Medit. Sea	32 18N.	16 36 E.	
I. Me- } tylene } C. Sigre	Af.	Natolia	Archipelago	39 21N.	26 08 E.	
				39 11N.	26 47 E.	
	Po. Olivier			39 00N.	26 50 E.	
I. Meun	Eu.	Denmark	Balt. Sea	55 00N.	13 15 E.	
Mexico	Am.	Mexico	Inland	20 00N.	103 35W	
I. St. Michael	Eu.	Azores	Atl. Ocean	38 13N.	22 50W	
Middleburg	Eu.	DutchInd.	Germ. Oce.	51 37N.	3 58 E.	
Milford	Eu.	Wales	St. Geo. Ch.	51 45N.	5 15W	5 15
Milo, I. Milo	Af.	Turkey	Archipelago	36 41N.	25 05 E.	
Mills's Isles	Am.	N. Main	Hudf. Bay	64 36N.	80 30W	

I. Min-

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
I. Mindanao { N. point				9 40N.	124 25 E.	
I. Mindanao { S. E. pt. C.						
I. Mindanao { Saint Auguſtine	Af.	Spice Ifles	South Sea	6 40N.	126 25 E.	
I. Mindanao { S.W.pt. Caldera				7 00N.	121 25 E.	
I. Mindanao { S. point				3 50N.	124 43 E.	
I. Mindora	Af.	Philip. Is.	South Sea	13 00N.	119 37 E.	
I. Minorca { N.W.pt.	Eu.	Spain	Medit. Sea	39 58N.	3 54 E.	
I. Minorca { S. E. pt.				40 24N.	4 18 E.	
I. Miſcou	Am.	Nov.Scot.	G. St. Lawr.	47 45N.	62 09W	
C. Miſerata	Af.	Guiney	Atl. Ocean	6 25N.	9 35W	
Miſſen Head	Eu.	Ireland	Atl. Ocean	51 16N.	11 30W	
R. Miſſiſſipi, mouth	Am.	Louifiana	G. Mexico	29 00N.	89 17W	
Mocha	Af.	Arabia	Red Sea	13 45N.	44 04 E.	
Modon	Eu.	Turkey	Medit. Sea	36 55N.	21 03 E.	
I. Mohilla	Af.	Zangueb.	Ind. Ocean	11 55 S.	45 00 E.	
I. Monferat	Am.	W. Indies	Atl. Ocean	16 37N.	62 13W	
Mont Real	Am.	Canada	R. Canada	45 52N.	73 11W	
I. Monte Chriſto	Eu.	Italy	Medit. Sea	42 17N.	10 28 E.	
C. Monte Sancto	Eu.	Turkey	Archipelago	40 27N.	24 39 E.	
Mount St.Michael	Eu.	France	Engl. Chan.	48 39N.	1 35 W	
I. Morgo	Af.	Natolia	Archipelago	36 55N.	26 30 E.	
Morlaix	Eu.	France	Eng. Chan.	48 30N.	3 50W	
Mort Point	Eu.	England	St. Geo. Ch.	51 12N.	4 40W	
Mofambique	Af.	Zangueb.	Ind. Ocean	15 00 S.	41 40 E.	
Mofcow	Eu.	Ruffia	R. Mofcow	55 36N.	40 25 E.	
Mofquitos Bank	Am.	Mexico	Atl. Ocean	14 45N.	80 05W	
C. Mount	Af.	Guinea	Atl. Ocean	7 12N.	10 44W	
Mounts Bay	Eu.	England	Engl. Chan.	50 05N.	5 45W	4h. 30m.
Mouſe River	Am.	New Wls	Hudſ. Bay	51 25N.	83 15W	
C. Muſaldon	Af.	Arabia	Perſ. Gulf	26 04N.	55 22 E.	
N						
C. Nabo	Af.	Japan	S. Ocean	40 35N.	141 25 E.	
Nangafack	Af.	Japan	South Sea	32 45N.	128 50 E.	
Nankin	Af.	China	South Sea	32 07N.	118 35 E.	
Nantes	Eu.	France	B. Biſcay	47 13N.	1 29W	3 00
Nantuck Iſle	Am.	New Eng.	W. Ocean	41 34N.	69 40W	
Naples	Eu.	Italy	Medit. Sea	40 51N.	14 45 E.	
Narbonne	Eu.	France	Medit. Sea	43 11N.	3 05 E.	
Narſinga	Af.	India	B. Bengal	18 05N.	85 20 E.	
Narva	Eu.	Livonia	G. Finland	59 08N.	29 18 E.	
I. Naſſau	Af.	Siam	Ind. Ocean	3 00 S.	100 25 E.	
C. Naſſau	Am.	Ter.Firm.	Atl. Ocean	7 53N.	58 07W	
Naſſau Str.	Eu.	Ruffia	N. Ocean	69 55N.	57 30 E.	
B. Natal	Af.	Caffers	Ind. Ocean	29 25 S.	33 10 E.	
I. Naxos	Eu.	Turkey	Archipelago	37 06N.	25 58 E.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Naze	Eu.	Norway	W. Ocean	57 50' N.	7 32' E.	11 h. 15 m.
Needles	Eu.	England	Eng. Chan.	50 41' N.	1 48' W.	9 45
C. Negrailles	Af.	Pegu	B. Bengal	16 20' N.	94 15' E.	
C. Negro	Af.	Caffres	Atl. Ocean	16 30' S.	11 30' E.	
C. Negro	Af.	Barbary	Medit. Sea	37 17' N.	9 09' E.	
Negropont	Eu.	Turkey	Archipelago	38 30' N.	24 05' E.	
Port Nelson	Am.	New Wls.	Hudf. Bay	57 07' N.	94 15' W.	
I. Nevis	Am.	Carib. Is.	Atl. Ocean	16 55' N.	62 42' W.	
Newcastle	Eu.	England	Germ. Ocean	55 03' N.	1 28' W.	5 15
R. Nicaragua	Am.	New Spain	Atl. Ocean	11 40' N.	82 47' W.	
Nice	Eu.	Italy	Medit. Sea	43 42' N.	7 22' E.	
Is. Nicobar	Af.	Siam	B. Bengal	7 22' N.	94 40' E.	
I. St. Nicholas	Af.	C. Verd	Atl. Ocean	17 05' N.	23 28' W.	
Nicotera	Eu.	Italy	Medit. Sea	38 33' N.	16 30' E.	
Nieuport	Eu.	Flanders	Germ. Ocean	51 08' N.	2 50' E.	12 00
Ninhay	Af.	China	South Sea	37 10' N.	122 25' E.	
Ningpo, or Liampo	Af.	China	S. Sea	30 00' N.	120 50' E.	
I. Nio	Eu.	Turkey	Archipelago	36 48' N.	26 02' E.	
I. Noel	Af.	India	Ind. Ocean	10 30' S.	105 25' E.	
C. de Non	Af.	Barbary	Atl. Ocean	28 04' N.	10 32' W.	
Nombre de dios	Am.	Ter. Fir.	Carib. Sea	9 43' N.	78 35' W.	
Nore	Eu.	England	R. Thames	51 28' N.	0 48' E.	0 00
C. North	Am.	Ter. Firm.	Atl. Ocean	1 45' N.	49 00' W.	
N. Cape, I. Maggoroe	Eu.	Lapland	N. Ocean	71 27' N.	26 30' E.	3 00
North Point	Eu.	Norway	N. Ocean	62 15' N.	6 15' E.	
I. Nottingham, } E. pt.	Am.	New Brit.	Hudf. Str.	63 33' N.	78 20' W.	
O						
Oczakow	Eu.	Turkey	Black Sea	45 12' N.	34 40' E.	
I. Oeland } S. end	Eu.	Sweden	Balt. Sea	56 15' N.	18 35' E.	
I. Oeland } N. end	Eu.	Sweden	Balt. Sea	57 23' N.	17 36' E.	
Old head of Kingsale	Eu.	Ireland	Atl. Ocean	51 35' N.	8 58' W.	
I. Oleron	Eu.	France	B. Biscay	45 51' N.	1 25' W.	
Olinde	Am.	Brazil	S. Atl. Ocean	8 13' S.	35 05' W.	
Oliva	Eu.	Germany	Balt. Sea	54 20' N.	18 30' E.	
Ollone	Eu.	France	B. Biscay	46 32' N.	1 36' W.	3 45
Oneglia	Eu.	Italy	Medit. Sea	43 57' N.	7 52' E.	
Oporto	Eu.	Portugal	Atl. Ocean	40 53' N.	8 35' W.	
Oran	Af.	Barbary	Medit. Sea	35 45' N.	0 00' W.	
C. Orange	Am.	Ter. Firm.	Atl. Ocean	4 27' N.	50 50' W.	
Orbitello	Eu.	Italy	Medit. Sea	42 30' N.	12 00' E.	
I. Orchillo	Am.	Ter. Firm.	Carib. Sea	11 32' N.	65 25' W.	
Orfordness	Eu.	England	Germ. Oce.	52 17' N.	1 11' E.	9 45
Orkney Isles, } limits	Eu.	Scotland	W. Ocean	59 24' N.	3 23' W.	3 00
New Orleans	Am.	Louisiana	R. Mississippi	30 00' N.	90 00' W.	
I. Ormus	Af.	Perfia	G. Perfia	27 30' N.	55 17' E.	
C. del Oro, or Olerada	Af.	Negro Ind	Atl. Ocean	23 30' N.	14 31' W.	
Oroque	Am.	Ter. Fir.	Atl. Ocean	08 08' N.	59 50' W.	

Names of Places.	Con.	Countries	Coast.	Latitude.	Longitud.	H. Water.
C. Oropeso	Eu.	Spain	Medit. Sea	40 20N.	0 49 E.	
C. Ortegál	Eu.	Spain	B. Biscay	44 07N.	8 00W	
Ortona	Eu.	Italy	Medit. Sea	42 19N.	14 37 E.	
I. Oruba	Am.	Ter. Firm.	Carib. Sea	12 03N.	69 03W	
Ostend	Eu.	Flanders	Germ. Océ.	51 14N.	3 00 E.	12h. ooms
C. Otranto	Eu.	Italy	Medit. Sea	40 23N.	17 41 E.	
Ozaca	Af.	Japon	South Sea	35 10N.	134 05 E.	
P						
C. Padron	Af.	Congo	Atl. Ocean	6 00 S.	11 40 E.	
Paita	Am.	Peru	South Sea	5 20 S.	80 35 W	
C. Paillouri	Eu.	Turkey	Archipelago	39 59N.	24 03 E.	
Palermo, I. Sicily	Eu.	Italy	Medit. Sea	38 10N.	13 43 E.	
Paliakate	Af.	India	B. Bengal	13 40N.	80 50 E.	
I. Palma	Af.	Canaries	Atl. Ocean	28 35N.	17 30W	
I. Palmaria	Eu.	Italy	Medit. Sea	41 00N.	13 03 E.	
C. Palmiras	Af.	India	B. Bengal	20 40N.	87 35 E.	
C. Palmas	Af.	Guiney	Atl. Ocean	4 26N.	5 56W	
Panama	Am.	Mexico	S. Ocean	8 45N.	79 55W	
I. Panaria	Eu.	Italy	Medit. Sea	38 40N.	15 41 E.	
Panorma	Eu.	Turkey	Medit. Sea	40 05N.	21 40 E.	
I. Pantalaria	Eu.	Italy	Medit. Sea	36 55N.	12 31 E.	
Panuco	Am.	Mexico	G. Mexico	24 02N.	100 13W	
R. Paraiba	Am.	Brazil	Atl. Ocean	21 26 S.	39 50W	
Paris	Eu.	France	R. Seine	48 50N.	2 25 E.	
C. Passero	Eu.	I. Sicily	Medit. Sea	36 35N.	15 22 E.	
C. Patam	Af.	Malacca	Indian Océ.	7 27N.	101 20 E.	
I. Patmos	Af.	Natolia	Archipelago	37 22N.	26 48 E.	
R. Pattahan	Af.	I. Sumatra	Str. Malaca	0 28N.	102 25 E.	
C. Paul	Eu.	Spain	Medit. Sea	37 50N.	0 15 W	
I. St. Paul	Am.	Newland	B. St. Lawr.	47 15N.	57 49W	
I. St. Paul	Af.		Ind. Ocean	38 20 S.	75 25 E.	
St. Paul de Leon	Eu.	France	Eng. Chan.	48 41N.	3 55 W	4 00
I. Paxeros	Am.	California	Pac. Ocean	30 18N.	120 45 W	
I. Pearl, or Serana	Am.	W. Indies	Atl. Ocean	14 55N.	79 00W	
Pegu	Af.	India	B. Bengal	17 00N.	96 58 E.	
Pekin	Af.	China	Inland	39 54N.	116 41 E.	
I. Pelugosa	Eu.	Italy	Adriat. Sea	42 20N.	18 32 E.	
I. Pemba	Af.	Zanguebar	Ind. Ocean	5 38 S.	40 09 E.	
C. Pembroke	Am.	New Wls.	Hudf. Bay	63 12N.	82 54 W	
I. Pengwin	Am.	Newf Ind.	Atl. Ocean	50 03N.	50 32W	
Penmark	Eu.	France	B. Biscay	47 50N.	4 20W	
R. Penobscut	Am.	New Eng.	Atl. Ocean	44 40N.	68 52W	
I. Pepys, or Penguin	Am.	Patagonia	S. Atl. Ocean	48 00 S.	64 50W	
Pernambuco	Am.	Brazil	S. Atl. Ocean	8 30 S.	35 07W	
Petapoli	Af.	India	B. Bengal	16 14N.	81 10 E.	
Petersbourg	Eu.	Russia	Balt. Sea	60 00N.	30 25 E.	
C. Petra	Af.	Natolia	Archipelago	37 02N.	27 38 E.	
Peverel Point	Eu.	England	Eng. Chan.	50 34N.	1 22W	
Philadelphia	Am.	Pennsylvan.	R. Delawar	40 50N.	74 00W	

St. Philip

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
St. Philip	Af.	Benguela	Atl. Ocean	12 22 S.	13 20 E.	
I. Pianosa	Eu.	Italy	Medit. Sea	42 46 N.	10 34 E.	
I. Pico	Eu.	Azores	Atl. Ocean	38 35 N.	26 20 W.	
C. Pinas	Eu.	Spain	B. Biscay	43 51 N.	6 14 W.	
Mo. Pintados, } or St. Martin }	Am.	California	S. Ocean	27 30 N.	117 15 W.	
Piscadore Isles	Af.	China	S. Sea	23 30 N.	119 25 E.	
Placentia	Am.	Newland	Atl. Ocean	47 36 N.	51 46 W.	
R. Plata	Am.	Magellan	Atl. Ocean	36 00 S.	57 40 W.	
R. Platewrack	Am.	Bahama I.	Atl. Ocean	20 04 N.	68 37 W.	
Plymouth	Eu.	England	Engl. Chan.	50 26 N.	4 27 W.	6h. oom.
Policaastro	Eu.	Italy	Medit. Sea	40 18 N.	15 45 E.	
Is. Polapate	Af.	Cambaya	Ind. Ocean	9 45 N.	109 55 E.	
I. Poma	Eu.	Dalmatia	Adriat. Sea	42 57 N.	18 14 E.	
Pondicherry	Af.	India	B. Bengal	11 54 N.	80 17 E.	
Pontorfon	Eu.	France	Engl. Chan.	48 33 N.	1 27 W.	
I. Ponza	Eu.	Italy	Medit. Sea	40 53 N.	13 09 E.	
Pool	Eu.	England	Engl. Chan.	51 00 N.	1 50 W.	
Porta Port	Eu.	Portugal	Atl. Ocean	40 53 N.	8 35 W.	
Port Mahon	Eu.	Spain	Medit. Sea	39 45 N.	4 19 E.	
Portland	Eu.	England	Eng. Chan.	50 30 N.	2 48 W.	8 C. 15
Port l'Orient	Eu.	France	Eng. Chan.	47 45 N.	3 18 W.	
Porto Bello	Am.	NewSpain	Carib. Sea	9 33 N.	79 45 W.	
I. Porto } Rico } E. pt. Porto Rico W. pt.	Am.	Antilles	Atl. Ocean	18 30 N.	65 35 W.	
I. Porto sancto	Af.	Canaries	Atl. Ocean	18 30 N.	67 15 W.	
Portfall	Eu.	France	Eng. Chan.	33 07 N.	15 53 W.	
Portsmouth	Eu.	England	Engl. Chan.	48 36 N.	4 43 W.	
Praken	Eu.	England	Engl. Chan.	50 49 N.	0 46 W.	0 00
Prenau	Af.	Coch. Chi.	Ind. Ocean	17 15 N.	106 15 E.	
I. Princes	Eu.	Livonia	Baltic Sea	58 26 N.	24 58 E.	
C. Prior	Af.	Guiney	Atl. Ocean	1 47 N.	6 39 E.	
I. Providence	Eu.	Spain	Atl. Ocean	43 53 N.	8 22 W.	
I. Providence, } or St. Catherine }	Am.	Bahama	Atl. Ocean	24 51 N.	77 01 W.	
I. Puli condor	Am.	Mexico	Atl. Ocean	13 26 N.	80 42 W.	
	Af.	Cambaya	Ind. Ocean	8 34 N.	107 35 E.	
Q						
Quaqua, or } Ivory Coast }	Af.	Guinea	Eth. Sea	5 00 N.	4 00 W.	
Quebeck	Am.	Canada	R. Canada	46 55 N.	69 48 W.	6 00
Queda	Af.	India	B. Bengal	6 15 N.	100 12 E.	
I. Quelpert	Af.	Korea	S. Sea	33 32 N.	128 04 E.	
Quiloa	Af.	Zangueb.	Ind. Ocean	9 30 S.	39 09 E.	
Quimper	Eu.	France	B. Biscay	48 00 N.	4 06 W.	
Quinam	Af.	Coch. Chi.	Ind. Ocean	12 52 N.	109 10 E.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
Rust Isles	Eu.	Norway	N. Sea	67 40N.	10 25 E.	
Rye	Eu.	England	Eng. Chan.	51 03N.	0 45 E.	11h. 15m.
S						
C. Sable	Am.	Nov.Scot.	Atl. Ocean	43 56N.	66 25W	
I. Sable	Am.	Nov.Scot.	Atl. Ocean	44 15N.	59 00W	
Saffia	Af.	Barbary	Atl. Ocean	32 30N.	8 50W	
I. Safanjal bahr.	Af.	Egypt	Red Sea	27 05N.	34 40 E.	
B. Saldanna	Af.	Caffers	Atl. Ocean	32 35 S.	19 30 E.	
I. Sal	Af.	C. Verde	Atl. Ocean	16 55N.	21 41W	
Salerno	Eu.	Italy	Medit. Sea	40 39N.	14 48 E.	
I. Salini, Lipari Is.	Eu.	Italy	Medit. Sea	38 39N.	15 24 E.	
I. Salisbury	Am.	N. Main	Hudf. Bay	63 35N.	77 00W	
Sallee	Af.	Barbary	Atl. Ocean	33 58N.	6 20W	
Salomon Isles	Af.		S. Sea	5 50 S.	171 05W	
Salonechi	Eu.	Turkey	Archipelago	40 41N.	23 13 E.	
I. Salvages	Af.	Canaries	N. Atl. Oce.	30 14N.	14 59W	
I. Samos	Af.	Natolia	Archipelago	37 46N.	27 13 E.	
Sandwich	Eu.	England	Downs	51 20N.	1 20 E.	
I. Sanguin	Af.	Philip. Is.	S. Sea	3 50N.	122 30 E.	
I. Sanien	Eu.	Norway	N. Ocean	69 30N.	14 30 E.	
Santa Cruz	Af.	Barbary	Atl. Ocean	30 36N.	9 35W	
I. Sardinia				41 15N.	9 31 E.	
N. limit						
S. pt. C. Ta						
volaro						
Cagliari	Eu.	Italy	Medit. Sea	38 54N.	9 15 E.	
Oristagni				39 25N.	9 38 E.	
Sarena	Am.	Chili	South Sea	39 53N.	9 01 E.	
Scanderoon	Af.	Syria	Levant	29 40 S.	71 15W	
Scarborough head	Eu.	England	Germ.Ocean	36 35N.	36 25 E.	
I. Scarpanto	Af.	Natolia	Archipelago	54 18N.	00 00 E.	3 45
Scaw	Eu.	Denmark	Sound	35 45N.	27 40 E.	
I. Schelling	Eu.	DutchInd.	Germ. Oce.	57 34N.	10 54 E.	
I. Scio				53 27N.	5 30 E.	
C. St. Ni-				38 38N.	26 12 E.	
cholas						
Scio	Af.	Natolia	Archipelago	38 24N.	26 29 E.	
C. Blanco				38 08N.	26 20 E.	
Scilly Isles	Eu.	England	St. Geo. Ch.	50 00N.	6 45W	3 45
Scots Settlement	Am.	Ter. Fir.	Carib. Sea	8 45N.	76 35W	
I. Sea	Eu.	Turkey	Archipelago	37 38N.	24 53 E.	
Seames	Eu.	France	B. Biscay	48 00N.	4 51W	
I. Sebaldes	Am.	Patagonia	S.Atl. Ocean	50 53 S.	59 35W	
C. Sebastian	Am.	California	South Sea	43 00N.	126 00W	
C. St. Sebastian	Af.	Madagaf.	Ind. Ocean	12 30 S.	49 13 E.	
St. Sebastian	Eu.	Spain	B. Biscay	43 16N.	2 05W	
Po. Segura	Am.	Brasil	Atl. Ocean	16 57 S.	39 45W	
R. Senegal	Af.	NegroInd	Atl. Ocean	15 40N.	16 20W	10 30
I. Seranilha	Am.	W. Indies	Atl. Ocean	16 20N.	79 40W	
I. Seriga	Eu.	Turkey	Archipelago	36 09N.	23 24 E.	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
I. Sertes	Af.	Canaries	Atl. Ocean	32 35'N.	16 20'W	
R. Seftos	Af.	Guinea	Atl. Ocean	5 48'N.	8 13'W	
Seven Capes	Af.	Barbary	Med. Sea	37 30'N.	6 15'W	
Seven Stones	Eu.	England	St. Geo. Ch.	50 10'N.	6 40'W	4h. 30m.
R. Severn, Ent.	Eu.	England	St. Geo. Ch.	51 41'N.	3 05'W	4 30
R. Seyn, Ent.	Eu.	France	Engl. Chan.	49 36'N.	0 30'E.	10 30
Seyn Head	Eu.	France	Eng. Chan.	49 44'N.	0 34'E.	
Sheerness	Eu.	England	R. Thames	51 25'N.	00 50'E.	1 00
Siam	Af.	India	B. Siam	14 18'N.	100 55'E.	
R. Siam, Ent.	Af.	India	B. Siam	13 15'N.	100 47'E.	
Siara	Am.	Brazil	Atl. Ocean	3 18'S.	39 50'W	
In. Sicily	C.	Italy	Medit. Sea	E. end, Messina	38 10'N.	15 58'E.
				Catanea	37 22'N.	15 21'E.
				Syracuse	37 04'N.	15 31'E.
				S. end,		
				Passaro	36 35'N.	15 22'E.
				Alicata	37 11'N.	14 07'E.
				W. end,		
Palermo	C.			Boeo	37 51'N.	12 43'E.
					38 10'N.	13 43'E.
Sierro Leona	Af.	Guinea	Atl. Ocean	8 30'N.	12 07'W	8 15
Sillabar Road	Af.	I. Sumatra	Ind. Ocean	4 00'S.	102 50'E.	
Str. Sincapore	Af.	Malaca	Ind. Ocean	1 00'N.	104 30'E.	
R. Sinda, or	Af.	India	Ind. Ocean	24 30'N.	63 10'E.	
Indus, mouth				25 45'N.	62 40'E.	
Po. Shabak	Af.	Abyssinia	Red Sea	18 58'N.	38 24'E.	
Shark, or Sea-	Am.	New Wls	Hudf. Bay	64 05'N.	82 12'W	
horse pt.						
Sheilds	Eu.	England	Germ. Oce.	55 02'N.	1 20'W	
Shelvoek's Isle	Am.	California	South Sea	23 15'N.	117 35'W	
Shillocks	Eu.	Ireland	West. Ocean	51 30'N.	11 55'W	
I. Shetland,	Eu.	Scotland	West. Ocean	60 47'N.	0 10'W	3 00
limits				59 54'N.	1 31'W	
Shoram	Eu.	England	Eng. Chan.	50 55'N.	00 17'E.	9 45
I. Sky	Eu.	Scotland	W. Ocean	57 50'N.	6 30'W	
N. pt.				57 15'N.	6 16'W	
Sleepers Isles	Am.	New Brit	Hudf. Bay	60 00'N.	81 30'W	
Sline Head	Eu.	Ireland	W. Ocean	53 20'N.	11 15'W	
R. Slude	Am.	New Brit	Hud. Bay	53 24'N.	78 50'W	
Sluyce	Eu.	Dutch Ind.	Germ. Oce.	51 19'N.	3 50'E.	
Smyrna	Af.	Natolia	Archipelago	38 28'N.	27 25'E.	
I. Socatora	Af.	Anian	Ind. Ocean	12 15'N.	52 55'E.	
C. Solomon	Eu.	I. Candia	Medit. Sea	34 57'N.	27 06'E.	
R. Somme	Eu.	France	Eng. Chan.	50 18'N.	1 40'E.	11 00
Sound royal	Eu.	Iceland	N. Ocean	66 22'N.	15 15'W	
Southampton	Eu.	England	Eng. Chan.	50 55'N.	1 30'W	0 00
C. Southampton	Am.	New Wls	Hudf. Bay	61 54'N.	86 14'W	
South Cape	Af.	Diemen's Ind.	S. Ocean	42 40'S.	130 05'E.	
C. Spartivento	Eu.	Italy	Medit. Sea	37 50'N.	16 41'E.	
C. Spartel	Af.	Barbary	Atl. Ocean	35 42'N.	5 47'W	

C. Spigu

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
C. Spigie	Af.	NewZeld.	S. Ocean	41 45 S.	162 50 E.	
I. Spirito sancto	Am.	Brafil	Atl. Ocean	20 24 S.	39 55 W.	
Spurn	Eu.	England	Germ. Oce.	53 35 N.	0 30 E.	5h. 15m.
I. Stampalia	Af.	Natolia	Archipelago	36 25 N.	26 55 E.	
I. Stancho	Af.	Natolia	Archipelago	36 50 N.	27 30 E.	
Start pt.	Eu.	England	Engl. Chan.	50 09 N.	2 45 W.	6 45
I. States {	Am.	Patagonia	Atl. Ocean	{	54 45 S.	60 35 W.
					55 08 S.	60 45 W.
Stavenger	Eu.	Norway	W. Ocean	58 47 N.	6 45 E.	
Stetin	Eu.	Germany	Balt. Sea	53 36 N.	15 25 E.	
C. Stillo	Eu.	Italy	Medit. Sea	38 23 N.	17 07 E.	
Port Steven	Am.	Chili	South Sea	46 50 S.	82 36 W.	
Stockholm	Eu.	Sweden	Baltic Sea	59 20 N.	19 30 E.	
Stockton	Eu.	England	Germ. Ocean	54 33 N.	1 15 W.	5 15
Straelsund	Eu.	Germany	Balt. Sea	54 23 N.	14 10 E.	
Stranford Bay	Eu.	Ireland	Irish Sea	54 23 N.	5 40 W.	
I. Stromboli	Eu.	Italy	Medit. Sea	38 42 N.	15 48 E.	
Suez Town	Af.	Egypt	Red Sea	29 50 N.	33 27 E.	
Sukadana	Af.	I. Borneo	Ind. Ocean	1 00 S.	110 40 E.	
I. Su- {	Af.	India	Ind. Ocean	{	5 15 N.	95 55 E.
					5 07 S.	106 20 E.
Sunderland	Eu.	England	Germ. Oce.	54 55 N.	1 00 W.	
Str. Sunda	Af.	Siam	Ind. Ocean	6 10 S.	105 35 E.	
Suranam	Am.	Ter. Firm.	Atl. Ocean	6 30 N.	55 30 W.	
Surat	Af.	India	Ind. Ocean	21 10 N.	72 25 E.	
I. Surroy	Eu.	Lapland	N. Ocean	71 00 N.	22 00 E.	
Swaken	Af.	Abassin	Red Sea	19 30 N.	37 38 E.	
Swally Road	Af.	India	Arab. Sea	21 55 N.	72 00 E.	
Swanfey	Eu.	Wales	St. Geo. Ch.	51 40 N.	4 25 W.	
Sweetnose	Eu.	Lapland	N. Ocean	68 08 N.	34 42 E.	
Swin, a sand	Eu.	England	Ent. Thames	51 37 N.	1 12 E.	12 00
Syracuse	Eu.	I. Scilly	Medit. Sea	37 04 N.	15 20 E.	
Syriam	Af.	Pegu	B. Bengal	16 00 N.	96 40 E.	
T						
Tadouzac Fort	Am.	Canada	R. Canada	48 00 N.	67 35 W.	
I. Tamarica	Am.	Brafil	Atl. Ocean	7 56 S.	35 05 W.	
Tamarin Town	Af.	I. Sokotra	Ind. Ocean	12 30 N.	53 14 E.	9 00
B. Tanassarini	Af.	Malacca	B. Bengal	12 00 N.	98 40 E.	
I. Tandoxima	Af.	Japan	S. Sea	30 30 N.	130 40 E.	
Tangier	Af.	Barbary	Atl. Ocean	35 55 N.	5 45 W.	
Tarento	Eu.	Italy	Medit. Sea	40 43 N.	17 31 E.	
R. Tees, mouth	Eu.	England	Germ. Oce.	54 36 N.	0 52 W.	3 00
Tegoantepec	Am.	Mexico	South Sea	14 45 N.	96 23 W.	
Tellichery	Af.	India	Mallab. coast	11 42 N.	75 30 E.	
C. Telling	Eu.	Ireland	W. Ocean	54 40 N.	10 07 W.	
I. Tenedos	Af.	Natolia	Archipelago	39 57 N.	26 14 E.	
I. Teneriff	Af.	Canaries	Atl. Ocean	28 23 N.	15 28 W.	3 00
						C. Tenes

Names of Places	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
C. Tenes	Af.	Barbary	Medit. Sea	36 26N.	1 53 E	
I. Tercera	Eu.	Azores	Atl. Ocean	39 00N.	24 52W	
Tervere	Eu.	Dutchlnd.	Germ. Oce.	51 38N.	3 35 E.	oh. 45m.
Tetuan	Af.	Barbary	Medit. Sea	35 27N.	4 50W	
I. Texel	Eu.	Dutchlnd.	Germ. Oce.	53 10N.	4 59 E	7 30
C. St. Thadæus	Af.	Siberia	N. Ocean	62 10N.	175 05 E.	
R Thames, mouth	Eu.	England	Germ. Oce.	51 28N.	1 10 E	
C. St. Thomas	Af.	Caffres	Atl. Ocean	24 54 S.	15 25 E.	
I. St. Thomas	Af.	Guinea	Atl. Ocean	00 00	1 00 E.	
St. Thomas	Af.	India	B. Bengal	13 00N.	80 00 E	
C. Three Points	Am.	Ter.Firm.	Atl. Ocean	10 51N.	62 41W	
C. Three Points	Af.	Guinea	Atl. Ocean	4 48N.	1 21W	
I. Tidore	Af.	Maluc. Is.	Ind. Ocean	0 35N.	126 40 E.	
I. Timor { NE.pt.	Af.	Maluc. Is.	Ind. Ocean	8 20 S.	127 40 E.	
I. Timor { SW.pt.				10 10 S.	123 55 E.	
Tinmouth	Eu.	England	Germ. Oce.	55 03N.	1 17W	3 00
I. Tino	Eu.	Turkey	Archipelago	37 33N.	25 43 E	
I. Tobago	Am.	Caribbe	Atl. Ocean	11 15N.	60 27W	
B. Todos sanctos	Am.	Brasil	Atl. Ocean	13 05 S.	38 45W	
Tonquin	Af.	India	South Sea	20 50N.	105 55 E.	
Tonsberg	Eu.	Norway	Sound	58 50N.	10 05 E.	
Topsham	Eu.	England	Engl. Chan.	50 37N.	3 27W	
Torbay	Eu.	England	Eng. Chan.	50 34N.	3 38W	5 15
Tornea	Eu.	Sweden	G. Bothnia	65 51N.	23 10 E.	
R. Tortosa	Eu.	Spain	Medit. Sea	40 47N.	1 03 E.	
I. Tortuga	Am.	Ter.Firm.	Atl. Ocean	11 00N.	64 23W	
I. Tory	Eu.	Ireland	W. Ocean	55 09N.	8 30W	
Toulon	Eu.	France	Medit. Sea	47 07N.	6 02 E.	
C. Trefalgar	Eu.	Spain	Atl. Ocean	36 06N.	5 38W	
I. Tremiti	Eu.	Italy	Medit. Sea	42 09N.	15 40 E.	
C. de Tres forcas	Af.	Barbary	Medit. Sea	35 30N.	2 11W	
I. Trialles	Af.	India	Ind. Ocean	19 30 S.	101 25 E.	
I. Trinity	Am.	Brasil	Atl. Ocean	20 25 S.	23 35W	
I. Trinidad, { E. pt.	Am.	Ter.Firm.	Atl. Ocean	10 38N.	60 27W	
I. Trinidad, { Ent.	Am.	Newf Ind.	Atl. Ocean	48 55N.	50 20W	
Triest	Eu.	Carniola	Adriat. Sea	45 51N.	14 03 E.	
Trinquemali	Af.	I. Ceylon	Indian Oce.	8 50N.	83 24 E.	
Tripoli	Af.	Syria	Levant	34 53N.	36 07 E.	
Tripoly	Af.	Barbary	Medit. Sea	32 54N.	13 10 E.	
G. Triste	Am.	Terra Fir.	Atl. Ocean	10 19N.	67 41W	
I. Tristian d'A- { cunha	Af.	Caffres	S. Atl. Ocean	37 12 S.	13 23W	
Is. Tromsund	Eu.	Lapland	N. Ocean	70 20N.	19 00 E.	
Truxilla	Am.	Peru	South Sea	8 00 S.	78 35W	
Tunder	Eu.	Denmark	W. Ocean	55 00N.	9 35 E.	
Tunis	Af.	Barbary	Medit. Sea	36 47N.	10 16 E.	
Turin	Eu.	Italy	R. Po	44 50N.	7 45 E.	
I. Turks	Am.	Bahama	Atl. Ocean	21 45N.	70 30W	

Names of Places.	Con.	Country.	Coast.	Latitude.	Longitud.	H. Water.
V						
Valencia	Eu.	Spain	Medit. Sea	39 30N.	0 40W	
St. Valery	Eu.	France	Eng. Chan.	50 10N.	0 56E.	10h. 30m.
Valona	Eu.	Turkey	Med. Sea	40 55N.	21 15E.	
Valparais	Am.	Chili	S. Ocean	33 00 S.	72 14W	
Vannes	Eu.	France	B. Biscay	47 39N.	2 41W	0 15
C. Vela	Am.	Ter.Firm.	Atl. Ocean	12 15N.	71 20W	
Venice	Eu.	Italy	Medit. Sea	45 25N.	12 10 E.	
Vera Cruz	Am.	NewSpain	G. Mexico	19 00N.	97 53W	
C. Verd	Af.	NegroInd.	Atl. Ocean	14 43N.	17 05W	
I. Verkins	Af.	Siam	Ind. Ocean	2 22N.	96 48E.	
Uhma	Eu.	Sweden	G. Bothnia	63 45N.	21 10 E.	
Vicegapatam	Af.	India	B. Bengal	17 30N.	84 02 E.	
C. Victory	Am.	Patagonia	S. Ocean	52 05 S.	72 50W	
Vienna	Eu.	Germany	R. Danube	48 13N.	16 28 E.	
Vigo	Eu.	Spain	Atl. Ocean	42 00N.	8 35W	
B. St. Vincent	Am.	Paraguay	Atl. Ocean	23 55 S.	45 11W	
C. St. Vincent	Eu.	Portugal	Atl. Ocean	36 41N.	8 42W	
I. St. Vincent	Af.	C. Verd	Atl. Ocean	17 17N.	23 44W	
I. St. Vincent	Am.	Caribbe	Atl. Ocean	13 05N.	61 05W	
R. St. Vincent	Af.	Guinea	Eth. Ocean	4 30N.	7 41W	
C. Virgin Mary	Am.	Patagonia	Atl. Ocean	52 15 S.	64 20W	
I. Virgins	Am.	Antil. Is.	Atl. Ocean	18 28N.	64 41W	
C. Volo	Eu.	Turkey	Archipelago	39 07N.	23 23 E.	
R. Voltas	Af.	Guinea	Atl. Ocean	5 52N.	1 10 E.	
C. Voltas	Af.	Caffres	Atl. Oce.	28 04 S.	16 18 E.	
Upfal	Eu.	Sweden	R. Sala	59 52N.	17 50 E.	
Uraniberg	Eu.	Denmark	Balt. Sea	55 54N.	12 58 E.	
I. Ushant	Eu.	France	Eng. Chan.	48 30N.	4 55W	6 00
I. Ustica	Eu.	Italy	Medit. Sea	38 43N.	13 33 E.	
I. Vulcano	Eu.	Italy	Medit. Sea	38 29N.	15 33 E.	
W						
R. Wager	Am.	New Wales	Hudf. Bay	61 05N.	89 37W	
C. Walsingham	Am.	New Brit.	Hudf. Str.	62 42N.	78 00W	
Wardhus	Eu.	Lapland	N. Ocean	70 35N.	32 45 E.	
Warsaw	Eu.	Poland	R. Vistula	52 14N.	21 10 E.	
Waterford	Eu.	Ireland	St. Geo. Ch.	52 07N.	7 52W	4 30
Watling Isle	Am.	Bahama	Atl. Ocean	23 42N.	74 22W	
Wells	Eu.	England	Germ. Oce.	53 07N.	1 00 E.	6 00
Western Isles	Af.	Diemen'slnd	S. Ocean	42 50 S.	138 40 E.	
Western Isles	S. pt.	Eu.	Scotland	56 46N.	7 40W	
Isles	N. pt.			58 35N.	6 37W	
Is. Westmania	Eu.	Iceland	W. Ocean	63 55N.	25 30W	
I. Westrol	Eu.	Lapland	N. Ocean	69 15N.	24 00 E.	
Wexford	Eu.	Ireland	St. Geo. Ch.	52 13N.	7 16W	
Weymouth	Eu.	England	Eng. Chan.	50 40N.	2 34W	6 00
Whale's Back	Eu.	Iceland	W. Ocean	63 44N.	17 05W	
Whale's Head	Eu.	Greenlnd	N. Ocean	77 18N.	21 30 E.	
Whale Rock	Eu.	Azores	Atl. Oce.	39 49N.	22 35W	
Whitby	Eu.	England	Germ. Oce.	54 30N.	0 50W	3 00

White-

Names of Places.	Con.	Countries.	Coast.	Latitude.	Longitud.	H. Water.
Whitehaven	Eu.	England	Irish Sea	54 25 N.	3 15 W	
Wicklow	Eu.	Ireland	St. Geo. Ch.	52 50 N.	6 30 W	
Windaw	Eu.	Courland	Balt. Sea	57 08 N.	22 20 E.	
Wight { N. end S. end E. end W. end I. Wight	Eu.	England	Engl. Chan.	50 47 N.	1 25 W	
				50 34 N.	1 25 W	
				50 41 N.	1 09 W	oh. oom.
				50 41 N.	1 46 W	
Is. Prince William	Af.		S. Sea	16 45 S.	177 55 E.	
Winchelsea	Eu.	England	Engl. Chan	50 58 N.	0 50 E.	0 45
Wintertonefs	Eu.	England	Germ. Oce.	53 02 N.	1 22 E.	9 00
Wisbuy in I. { Gotland	Eu.	Sweden	Balt. Sea	57 40 N.	19 50 E.	
C. Wrath, or { Faro head						
Wybourg	Eu.	Finland	G. Finland	60 55 N.	30 20 E.	
Y						
Yamboa	Af.	Arabia	Red Sea	24 25 N.	38 54 E.	
Yarmouth	Eu.	England	Germ. Oce.	52 55 N.	1 40 E.	9 45
Yas de Amber	Af.	Zangueb.	Ind. Ocean	0 00 N.	47 15 E.	
Yellow River	Af.	China	S. Sea	34 06 N.	120 10 E.	
Ylo	Am.	Peru	South Sea	17 36 S.	71 08 W	
York Fort	Am.	New Wls.	Hudf. Bay	56 55 N.	94 05 W	
York new	Am.	New Eng.	Atl. Ocean	41 05 N.	74 15 W	
Youghall	Eu.	Ireland	St. Geo. Ch.	51 46 N.	7 46 W	4 30
Z						
Zacatula	Am.	Mexico	South Sea	17 10 N.	105 00 W	
I. Zant	Eu.	Italy	Adriat. Sea	37 50 N.	21 30 E.	
I. Zanzebar	Af.	Zangueb.	Ind. Ocean	6 55 S.	40 10 E.	
Zaro	Eu.	Dalmatia	Mediterr. Sea	44 15 N.	16 55 E.	
New Zealand { NW. pt. C. Spigie	Af.		S. Ocean	34 20 S.	165 40 E.	
				41 45 S.	162 50 E.	
Zenan city	Af.	Arabia	Inland	16 20 N.	47 44 E.	
Zerick Sea	Eu.	Dutchlnd.	Germ. Oce.			3 00

Beside the times of high water in the preceding Table, the following ones serve for coasts of considerable extent, and will nearly serve for the places on those coasts.

Finmark, or NNW. coast of Lapland, 1 h. 30 m. Jutland Isles oh. 0 m.
 Friesland coast 7 h. 30 m. Zeland coast 1 h. 30 m.
 Flanders coast oh. 00 m. Picardy and Normandy coasts 10 h. 30 m.
 Biscay, Gallician and Portugal coasts 3 h. 00 m.
 Irish W. coast 3 h. 00 m. Irish S. coast 5 h. 15 m.

T H E



THE
ELEMENTS
OF
NAVIGATION.

BOOK VI.
OF PLANE SAILING.

SECTION I.
Definitions and Principles.

660. **N**AVIGATION is the art of conducting a ship from one port to another.

This art may be divided into two parts; namely, Mechanical and Theoretical.

MECHANICAL, or **WORKING NAVIGATION**, comprehends the art of working a ship; that is, of causing it to observe such motions and directions as are assigned by the Navigator.

This art must be learned on shipboard, and in the practice of sailing.

THEORETICAL NAVIGATION, or the art of Piloting, concerns those methods whereby the Navigator, or Pilot, discovers in what tract the ship must steer, so as to arrive safely at the intended port.

The art of Piloting is either common or proper.

COMMON PILOTING is that knowledge which teaches how to coast along shore, or to sail within sight of land.

PROPER PILOTING is the art of sailing to distant places through the Ocean, and out of sight of land.

The art of proper piloting (which partly includes that of common piloting) chiefly depends on a right application of the principles contained in the preceding books.

661. The navigating or conducting a ship thro' the Ocean to distant countries, depends on the Navigator's being beforehand furnished with the following elements.

1st. A Table of the latitudes and longitudes of the most remarkable parts of the Sea coasts, Islands, Rocks, Shoals, &c. in the frequented parts of the world.

2d. Maps or Charts of the Seas and Lands; together with the depths of water, and the times and setting of the tides upon the coasts he may have occasion to approach near.

3d. The use and application of several Instruments necessary to point out the way the ship is to steer, to measure the rate she runs at, and to find the place she is in at any time.

4th. A sufficient stock of Mathematical learning to enable him rightly to use the observations that may be deduced from the preceding elements.

The latitudes and longitudes of places cannot be otherwise obtained, than from proper observations made by persons who have been in those places: consequently, the collecting a sufficient number of these must be the work of many ages. And hence arises the great uncertainty of the positions of many places, and even of the little knowledge we have of many parts on the surface of the Terraqueous globe. See Table, at art. 659.

662. The Maps of Countries, and the Charts of the Ocean and their boundaries, are made chiefly from the catalogue of the latitudes and longitudes of places: But where these are partly wanting, and a good collection of the positions and distances of places can be obtained, those places may be inserted in the map as truly as the others whose latitudes and longitudes are known.

The most natural way of delineating the surface of the earth, is to do it on a sphere; for then every place on the Globe, laid down by its latitude and longitude, will have the same position with respect to other places, as they really have on the surface of the earth. But as a Globe is a bulky thing, and not so easily managed or worked on as a plane is; therefore has the representation of the surface of the earth been made on planes, and these are called *Maps* or *Charts*.

In the constructing of Maps and Charts, great care should be taken, that the several parts in them preserve their position one to the other in the same order as they do on the Earth; and 'tis likely, that the finding out of proper methods to do this, gave rise to the several methods of projection.

663. There are many ways of constructing Maps and Charts; but they chiefly depend on two principles.

First,

First, From considering the earth as a large extended flat surface: The Charts made on this supposition, are usually called PLANE CHARTS.

Secondly, From considering the earth as a sphere: The Charts made on this principle are sometimes called GLOBULAR CHARTS, or MERCATORS CHARTS, or REDUCED CHARTS, or PROJECTED CHARTS.

Plane Charts, when made for any large extent of several degrees in high latitudes, are very erroneous; for in them the difference of longitude between any two Meridians, taken at the Equator, is used as the distance of those meridians in all latitudes; and consequently the distances of places in high latitudes will be too great, and thereby their due positions will not be preserved: But Charts made for a small part, as a degree or two in length and breadth, may be reckoned as tollerably exact, especially if those places be within the *Torrid Zone*; nay, a Plane Chart made for all this Zone will differ but little from the truth.

S E C T I O N II.

664. *The construction and use of the Plane Chart.*

CONSTRUCTION.

1st. Having determined the limits of the Chart, that is, how many degrees of latitude and longitude, or meridional distance, (they being in this Chart the same) it is to contain: Suppose from the lat. of 20° N. to the lat. of 71° N; and from the longitude of London in 0 deg. to the lon. of 50° W.; then fix on some scale of equal parts, such whereby the chart may be contained within the size of the sheet it is intended to be drawn on. In the chart annexed, see Plate II. the scale is such, that each degree of latitude and longitude is $\frac{1}{8}$ th part of an inch.

2d. Make a parallelogram (160) ABCD, whose length AB from north to south shall contain 51 degrees, the difference of latitude between the limits of 20° and 71° ; and the breadth AD from east to west shall contain the proposed 50 degrees of longitude, the degrees being taken from the said scale of 8 degrees to an inch; and this parallelogram will be the boundaries of the chart.

3d. About the boundaries of the chart, make (172) scales containing the degrees, halves and quarters of degrees (if the scale is large enough); drawing lines across the chart thro' every 5 or 10 degrees; and the sheet is then fitted to receive the places intended to be delineated thereon.

4th. On a strait slip of pastboard, or stiff paper, let the scale of the degrees and parts of degrees of longitude in the line AD, be laid close to the edge; and the divisions numbered from the right hand towards the left, being all west longitude.

H h 2

5th.

5th. Seek in the table (art. 659) for the latitudes and longitudes of the places contained within the proposed limits; and let them be wrote out in the order in which they increase in latitude.

6th. Then to lay down any place, lay the edge of the pastboard scale to the divisions on each side the chart, shewing the latitude of the place; so that the beginning of its divisions fall on the right hand border AB; and against the division shewing the longitude of the given place make a point, and this gives the position of the place proposed; and in like manner are all the other places to be laid down.

7th. Draw waving lines from one point to the other, where the coast is contiguous, and thus the representation of the lands within the proposed limits will be delineated.

8th. Write the names to the respective parts, and in some convenient place insert a compass, and the chart will be compleated.

The use of the Plane Chart.

665. To find the lat. and lon. of any proposed place in the Chart.

Take with a pair of compasses the least distance between the given place and some parallel of latitude; this distance applied (the same way) to the graduated meridian on the border of the chart, keeping one point on the same parallel of latitude, the other point will shew the degrees of latitude the proposed place is in.

And in like manner, the distance between the given place and some meridian, applied (the same way) to the graduated parallel on the top or bottom of the chart, will shew its degrees of longitude.

Thus the distance between Cape Finesterre and the parallel of latitude of 40° , laid on the border from 40° upwards, gives $43^{\circ} 15' N.$ for Cape Finesterre's latitude: And the distance of the Cape from the Meridian passing thro' 10° of longitude, being laid on the bottom border from 10° towards the right, gives $9^{\circ} 20' W.$ for the longitude.

666. Two places being given, suppose Cape Clear and the Island of St. Michael's, to find the bearing and distance between them.

Lay a ruler by the two places, C. Clear and St. Michael's, take the nearest distance between the centre of the compass and the edge of the ruler; in this position slide one point along the ruler, and the other point will run along that point of the compass shewing the bearing, which in this case is S. W.; that is, St. Michael's lies to the S. W. of C. Clear, or C. Clear to the N. E. of St. Michael's.

The distance between the two places applied to the graduated parallel from 0 degrees, will give the number of degrees, which converted into miles shews their distance.

Thus the distance from Cape Clear to St. Michael's will be found to be about $15^{\circ} 25'$, which multiplied by 60 gives 925 miles.

667. *The distance sailed on a given course, and from a given place, being known, to find the place the ship is in. Thus suppose a ship sails from Cape Clear S.W. for 925 miles: Required her present place?*

Reduce the given miles (925) into degrees and minutes, and take them ($15^{\circ} 25'$) with one pair of compasses from the graduated scales.

Lay a ruler by the centre and the given point of the compass (S.W.); take the nearest distance between (Cape Clear) the place sailed from and the edge of the ruler with another pair of compasses; in this position, slide one point along the ruler until the other point is got as far distant from the given place as is the given distance, which is found by applying the opening of the other pair of compasses from (Cape Clear) the given place, till the points of both pair of compasses meet; and that will give the present place of the ship, which will be found in the latitude and longitude of St. Michael's; and these are known by art. 665.

The Mariner working by the preceding precepts will preserve his chart free from a multitude of lines: But when this is not regarded (as indeed it is scarcely worth while), the operations will become somewhat shorter.

668. *The latitude of a place (A), and its bearing from a given place (B) being known; to find that place (A) on the chart, and its distance from B.*

Thro' the given place B draw a line parallel to the given point of the compass, or bearing; then an east and west line drawn thro' the latitude of A, its intersection with the former line will give the place sought. The distance may be measured as in art. 666.

669. *The latitude of a place (A), and its distance from a given place (B) being known; to find the place of A on the chart.*

Draw an east and west line thro' the latitude of A; take the given distance in degrees from the graduated scale; then this distance being applied from the given place B will cut the said east and west line in the required place of A.

670. *The longitude of a place A, and its bearing from a given place B being known; to find the place of A on the chart.*

Draw a meridian thro' the longitude of A; then the given distance taken as before and applied from B, will cut the said meridian in the required place of A.

671. *The longitude of a place A, and its bearing from a given place B being known; to find the place of A on the chart.*

Thro' the given place B draw the given bearing. (666)

Draw a meridian thro' the longitude of A, and its intersection with the said bearing will be the place of A.

And in this manner may every possible case of sailing by the plane chart be readily solved: But as the accuracy of these solutions cannot be depended upon nearer than 5 or 6 minutes more or less than the truth; therefore the more careful Navigators depend on computation, as will be shewn in the following sections.

SECTION

SECTION III.

Of Plane Sailing.

672. PLANE SAILING is the art of navigating a ship upon principles deduced from the notion of the earth's being an extended plane.

On this supposition, the meridians are esteemed as parallel right lines, the parallels of latitude are at right angles to the meridians, the lengths of the degrees on the meridians, equator and parallels of latitude, are every where equal; and the degrees of longitude are reckoned on the parallels of latitude as well as on the equator.

673. The PLANE CHART is a map or representation of the several parts of the earth, laid down from these principles, according to their latitudes and longitudes, on a sheet of paper, or other flat surface. (664)

When the parts of the earth are thus delineated on a plane, it is easy to see the tracks by which a ship may go from one place to another; and also what angle this track makes with the meridian: And ships at sea are kept in this track or path by the help of an instrument called the Mariner's Compass.

674. The MARINER'S COMPASS is an artificial representation of the horizon of every place, by the means of a circular piece of paper called a Card, divided like the horizon into degrees and points, which are called Rhumbs: Now the card being properly fixed to a piece of steel called a Needle, that has been touched with a loadstone (whose property is such as to cause one end of the needle, so touched, to point towards the north, when turning freely on something supporting it), all the points of the card will be directed towards their corresponding points of the horizon.

From this construction of the Mariner's compass it follows, that in every place the north point of the card shews the position of the meridian in that place; and some one rhumb or point of the card will coincide with, or be directed along, the track that makes any given angle with the meridian: Consequently by the help of the card or compass a ship may be kept on any proposed track or course.

675. A RHUMB LINE is a right line drawn from the centre of the compass to the horizon; and is named from that point of the horizon it falls in with.

676. The COURSE is an angle which any Rhumb line makes with the meridian, and is sometimes reckoned in degrees, and sometimes in points of the compass.

677. DISTANCE is the number of leagues, miles, &c. intercepted between two places reckoned on a Rhumb; or it is the way or length a ship has gone on a direct course in a given time.

678. DEPARTURE is the east or west distance of a ship from the meridian of some noted place, reckoned on its parallel of latitude in the Plane Chart; and therein it is the same as the difference of longitude.

679. If a ship sails either due north or south, she sails on a meridian, makes no departure, and her distance and difference of latitude are the same.

If a ship sails either due east or west, she runs on a parallel of latitude, makes no difference of latitude, and her departure and distance are the same.

680. The difference of latitude and departure always make the legs of a right angled triangle, whose hypotenuse is the distance the ship has sailed.

When the course is 45 degrees, or 4 points, the difference of latitude and departure are equal.

When the course is less than 45 degrees, or 4 points, the difference of latitude is greater than the departure.

But when the course is greater than 4 points, or 45 degrees, the departure is greater than the difference of latitude.

681. When a figure relating to a ship's course is to be constructed, it must first be considered whether the ship is sailing northward or southward; and whether she goes to the eastward or westward of the place she departed from; for the lines in the figure must be drawn accordingly.

Thus. Let the upper part of the paper, or what the figure is drawn on, always represent the north, then the lower part will be south, the right hand side east, and the left hand side the west.

Draw a north and south line to express the meridian of the place the ship sails from; then if the course is to the southward, mark the upper end of the line for the place sailed from: But if the course is northward, mark the lower end for that place.

Thro' the point sailed from, draw a line perpendicular to the meridian to represent the parallel of latitude of that place; and from the same point, with the chord of 60 degrees, describe a quadrantal arc on the east side of the meridian, if the course is eastward, or on the west side, if the course is to the westward.

When the course is given, the chord of the degrees, or points expressing it, is to be taken with a pair of compasses either from the scale of chords or of rhumbs*; and is always to be laid off on the quadrantal arc, beginning at the meridian.

The line expressing the distance the ship has run, is always to be drawn from the centre of the quadrant or point sailed from, thro' that point of its arc which limits the course.

The difference of latitude, in leagues or miles, taken with the compasses from a scale of equal parts, is ever to be laid on the meridian, reckoning from the centre of the quadrant.

* A quadrant, or arc of 90° , being divided into 8 equal parts, and each of these into quarters; then if from one end of the arc the several divisions be transferred to the chord of 90° , as in art. 213, a line of rhumbs is thereby constructed; whose use is the same as the chords, namely, to make an angle whose measure is given in points instead of degrees.

These proportions are here inserted to exercise the learner in reasoning on the relations subsisting between these lines and those representing the distance, departure and difference of latitude: But in what follows, only the analogies in the first column, and one against the last case in the second column, will be used; the others being rather matters of curiosity than use.

Cafe	Given	Req.	Solution by fines	Solution by tangents and secants	
—	—	—	by sim. $\triangle ADC, ABE$	by sim. $\triangle ADC, AFG$	by sim. $\triangle ADC, AHI$
1	$\angle A, AC$	AD DC	$AE:AB::AC:AD$ $AE:EB::AC:DC$	$AG:AF::AC:AD$ $AG:FG::AC:DC$	$AI:IH::AC:AD$ $AI:AH::AC:DC$
2	$\angle A, AD$	AC DC	$AB:AE::AD:AC$ $AB:BE::AD:DC$	$AF:AG::AD:AC$ $AF:FG::AD:DC$	$IH:AI::AD:AC$ $IH:AH::AD:DC$
3	$\angle A, DC$	AC AD	$BE:AE::DC:AC$ $BE:AB::DC:AD$	$FG:AG::DC:AC$ $FG:AF::DC:AD$	$AH:AI::DC:AC$ $AH:HI::DC:AD$
4	AD, AC	$\angle A$ DC	$AC:AD::AE:AB$ $AE:EB::AC:DC$	$AD:AC::AF:AG$ $AF:FG::AD:DC$	
5	AC, DC	$\angle A$ AD	$AC:DC::AE:EB$ $AE:AB::AC:AD$		$DC:AC::AH:AI$ $AH:HI::DC:AD$
6	AD, DC	$\angle A$ AC		$AD:DC::AF:FG$ $AF:AG::AD:AC$	$DC:AD::AH:HI$ $AH:AI::DC:AC$

685. To assist the learner, the proportions hereafter used are given in their nautical terms.

Cafe	Given	Required	SOLUTIONS.	
1	Course & Distance	Diff. lat. Depart.	Rad : Dist :: Cos. Cou : Diff. lat.	N° I.
			Rad : Dist :: sin. Cou : Depart.	N° II.
2	Course Diff. lat.	Distance Depart.	Cos. Cou : Diff. lat. :: Rad : Distance.	N° III.
			Cos. Cou : Diff. lat. :: sin. Cou : Depart. or by N° II.	
3	Course Depart.	Distance Diff. lat.	Sin. Cou : Depart. :: Rad : Dist.	N° IV.
			Sin. Cou : Depart. :: Cos. Cou : Diff. lat. or by N° I.	
4	Distance Diff. lat.	Course Depart.	Dist : Rad :: Diff. lat : Cos. Cou.	N° V.
			Rad : Dist :: sin. Cou : Depart. by N° II.	
5	Distance Depart.	Course Diff. lat.	Dist : Rad :: Depart : sin. Cou.	N° VI.
			Rad : Dist :: Cos. Cou : Diff. lat. by N° I.	
6	Diff. lat. Depart.	Course Distance	Diff. lat : Depart. :: Rad : tan. Cou.	N° VII.
			Sin. Cou : Depart. :: Rad : Dist. by N° IV.	

These proportions (or Canons as they are usually called by Mariners), are applied to the numeral solutions of all the varieties of single courses in the following section.

686. A TABLE of the angles which every Rhumb, or point of the compass, makes with the meridian.

NORTH.	SOUTH.	Points.	D.	M.	NORTH.	SOUTH.
		0 $\frac{1}{4}$	2	49		
		0 $\frac{1}{2}$	5	37 $\frac{1}{2}$		
		0 $\frac{3}{4}$	8	26		
N. b. E.	S. b. E.	1 0	11	15	N. b. W.	S. by W.
		1 $\frac{1}{4}$	14	04		
		1 $\frac{1}{2}$	16	52 $\frac{1}{2}$		
		1 $\frac{3}{4}$	19	41		
N. N. E.	S. S. E.	2 0	22	30	N. N. W.	S. S. W.
		2 $\frac{1}{4}$	25	19		
		2 $\frac{1}{2}$	28	07 $\frac{1}{2}$		
		2 $\frac{3}{4}$	30	56		
N. E. by N.	S. E. b. S.	3 0	33	45	N. W. b. N.	S. W. b. S.
		3 $\frac{1}{4}$	36	34		
		3 $\frac{1}{2}$	39	22 $\frac{1}{2}$		
		3 $\frac{3}{4}$	42	11		
N. E.	S. E.	4 0	45	00	N. W.	S. W.
		4 $\frac{1}{4}$	47	49		
		4 $\frac{1}{2}$	50	37 $\frac{1}{2}$		
		4 $\frac{3}{4}$	53	26		
N. E. b. E.	S. E. b. E.	5 0	56	15	N. W. b. W.	S. W. b. W.
		5 $\frac{1}{4}$	59	04		
		5 $\frac{1}{2}$	61	52 $\frac{1}{2}$		
		5 $\frac{3}{4}$	64	41		
E. N. E.	E. S. E.	6 0	67	30	W. N. W.	W. S. W.
		6 $\frac{1}{4}$	70	19		
		6 $\frac{1}{2}$	73	07 $\frac{1}{2}$		
		6 $\frac{3}{4}$	75	56		
E. b. N.	E. b. S.	7 0	78	45	W. b. N.	W. b. S.
		7 $\frac{1}{4}$	81	34		
		7 $\frac{1}{2}$	84	22 $\frac{1}{2}$		
		7 $\frac{3}{4}$	87	11		
EAST.	EAST.	8 0	90	00	WEST.	WEST.

Before the learner begins his cases of Plane sailing, he should be so well acquainted with his Compass, or this table, as to be readily able to tell how many points any of these courses or Rhumbs are distant from the meridian, or from the parallel.

SECTION

SECTION IV.

Of single courses.

687. CASE I. Given the course steered, and the distance run:
Required the difference of latitude and departure.

EXAM. A ship from the latitude $47^{\circ} 30' N.$ has sailed S. W. b. S. 98 miles: What Lat. is she in, and what Dep. has she made?

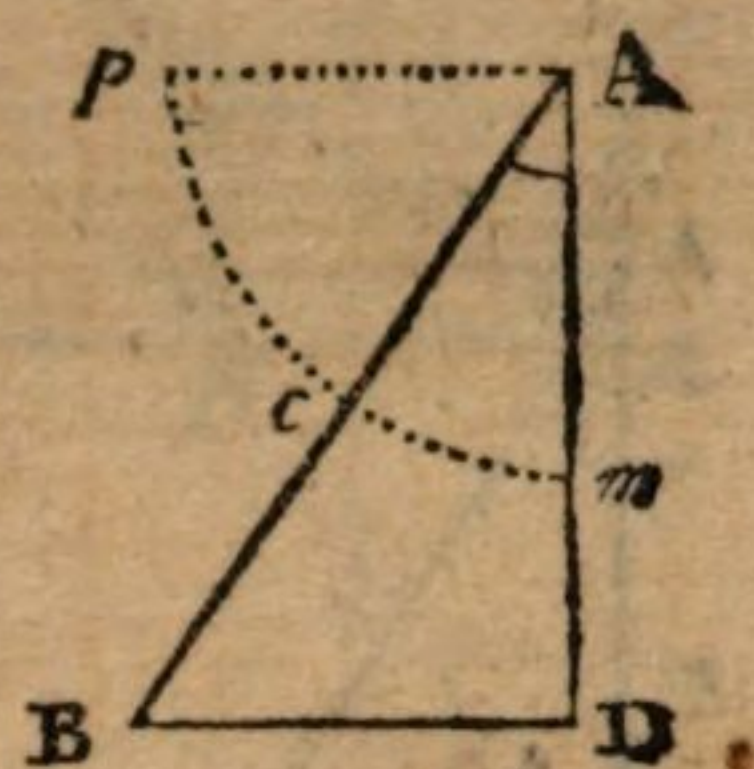
BY THE TRAVERSE TABLE. (711)

Find the given course at the top or bottom of the table among the points or degrees; and in that column, right against the distance taken in its column, stand the diff. lat. and departure in their columns.

Thus the course is S. W. b. S. or 3 points, in which column, and against the distance 98 in the column of distances, stand 81,5 miles for the diff. lat.; and 54,45 miles for the departure.

By CONSTRUCTION. (681)

1. Draw the meridian AD, and make the quadrant $A m c p$.
2. Make mc = rhumb of 3 points, and thro' c draw AB equal to 98 miles.
3. Draw BD parallel to pc , meeting AD in D.
Then AD the diff. lat. measures about $81\frac{1}{2}$ miles.
And DB the departure measures about 54,4 miles.



By COMPUTATION.

The course being 3 points = $33^{\circ} 45'$.			The comp. course is 5 pts. = $56^{\circ} 15'$.		
To find the diff. latitude.			To find the departure.		
As Rad	= $90^{\circ} 00'$	10,00000	As Rad	= $90^{\circ} 00'$	10,00000
To Dist.	= 98 m.	1,99123	To Dist.	= 98 m.	1,99123
So cos. Co.	= $33^{\circ} 45'$	9,91985	So sin. Cou.	= $33^{\circ} 45'$	9,74474
To diff. lat.	= 81,48	1,91108	To Dep.	= 54,45	1,73597

By GUNTER'S SCALE.

On the line of fine Rhumbs, the extent from Rad. or 8 points to 3 points, applied to the line of numbers will reach from 98 in either scale to 54,4.

And the extent from 8 points to 5 points among the Rhumbs, reaches from 98 to 81,5 on the line of numbers.

Or thus. The extent from Radius or 8 points in the S. R. to 98 in the Nos. will reach from 3 points in the Rhumbs to 54,4 in the Nos. and the same extent will reach from 5 points in the Rh. to 81,5 in the Nos.

60)81(
 The Lat. from $47^{\circ} 30' N.$
 diff. Lat. 1 21 S.

1° 21'

Lat. in 46 09 N. Dep. 54,4 miles West.

The lines on the Gunter's scale marked S. R. and T. R. signifying *Sine Rhumbs* and *Tangent Rhumbs*, are the logarithmic sines and tangents answering to the degrees and minutes in each point and quarter point of the Compass, transferred from the scales of Log. sines and Log. tangents.

688. CASE II. Given the course steered, and difference of latitude:
Required the distance run, and the departure.

EXAM. *A ship has sailed S. E. b. S. from the Lat. $47^{\circ} 30' N.$ to the Lat. $46^{\circ} 08' N.$ What distance has she run, and what departure has she made?*

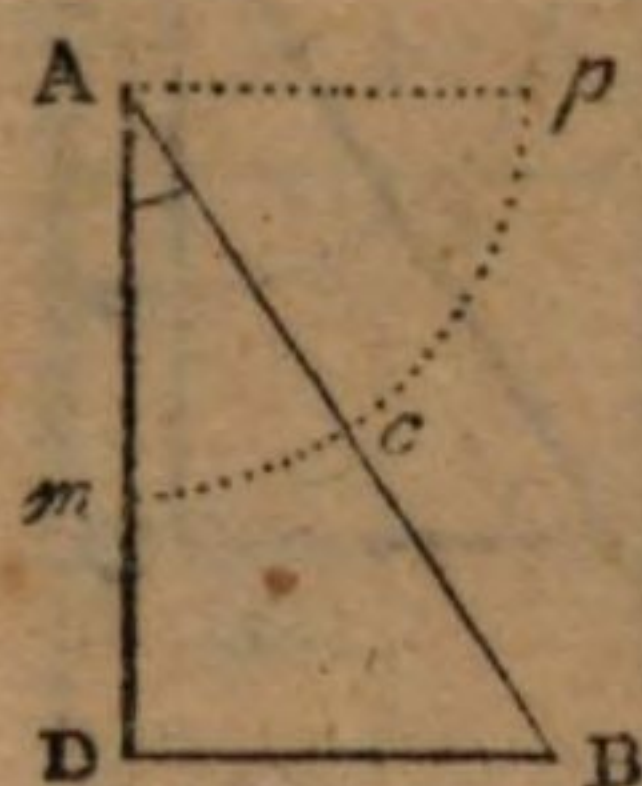
BY THE TRAVERSE TABLE. (711)

Find the course among the degrees, and the diff. lat. in its column, right against which stand the departure and distance in their columns.

Now taking $46^{\circ} 08'$ from $47^{\circ} 30'$, Remains $1^{\circ} 22' = 82$ m. the diff. lat.

Then the course S. E. b. S. is 3 points, under which in the column of Lat. the nearest number to 82 is 82,3, the corresponding departure is 55, and the distance is 99 miles.

BY CONSTRUCTION.



1st. Describe the quadrant $A m c p$.

2d. Make $mc =$ rhumb of 3 points, and continue Am till $AD = 82$ miles.

3d. Thro' D draw DB parallel to Ap , meeting the line AB drawn thro' c , in the point B .

Then the distance AB measures about 99 miles.

And the departure DB measures about 55 miles.

BY COMPUTATION.

The course 3 points $= 33^{\circ} 45'$.			The comp. course is 5 pts. $= 56^{\circ} 15'$.		
To find the distance.			To find the departure.		
As cof. Co.	$= 33^{\circ} 45'$	0,08015	As cof. Co.	$= 33^{\circ} 45'$	0,08015
To diff. lat.	$= 82$ m.	1,91381	To diff. lat.	$= 82$ m.	1,91381
So Rad	$= 90^{\circ} 00'$	10,00000	So fin. Cou.	$= 33^{\circ} 45'$	9,74474
To Dist.	$= 98,62$	<u>1,99396</u>	To Dep.	$= 54,79$	<u>1,73870</u>

BY GUNTER'S SCALE.

On the line of fine Rhumbs, the extent from 5 points to 8 points or radius, will on the line of numbers reach from 82 to 99.

And the extent from 5 points to 3 points on the S. R. will reach from 82 to 55 on the line of numbers.

Or thus, The extent from 5 points in the fine rhumbs, to 82 miles in the line of numbers, will reach from 8 points in those rhumbs to 99 in the numbers; and the same extent will reach from 3 points in the rhumbs to 55 in the numbers.

Note. In all these cases, wherever the cof. Cou. is used, the deg. put down is the course itself, yet the log. belongs to the comp. of that course.

689. CASE III. Given the course steered and the departure:
Required the dist. run, and diff. latitude.

EXAM. *A ship from Lat. $47^{\circ} 30'$ N. sailing N. W. b. W. finds she has made 82 miles of departure: What is her distance run, and what Lat. is she now in?*

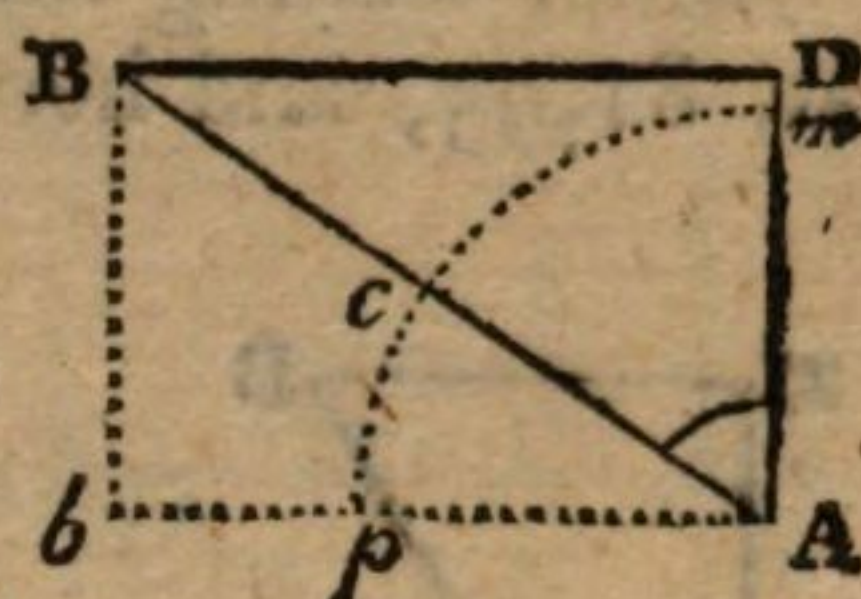
BY THE TRAVERSE TABLE. (711)

Find the course among the degrees, and the departure in its column; right against which stand the difference of latitude and the distance in their respective columns.

Now the course N. W. b. W. is 5 points, over which in the column of departure, the nearest number to 82, is 82,3; and the corresponding diff. latitude is 55 miles, and the distance is 99 miles.

BY CONSTRUCTION.

- 1st. Describe the quadrantal arc $A m c p$.
- 2d. Make mc = rhumb of 5 points, and continue $A p$ till $A b = 82$ miles.
- 3d. Thro' b draw $b B$ parallel to $A m$, meeting the line AB , drawn thro' c , in B .
- 4th. Thro' B draw BD parallel to $b A$, meeting $A m$ continued, in D .



Then the distance AB measures about 99 miles.
And the diff. lat. AD measures about 55 miles.

BY COMPUTATION.

The course 5 points is $56^{\circ} 15'$.			The comp. course is 3 pts. = $33^{\circ} 45'$.		
To find the distance.			To find the diff. latitude.		
As fin. Co.	= $56^{\circ} 15'$	0,08015	As fin. Co.	= $56^{\circ} 15'$	0,08015
To dep.	= 82 m.	1,91381	To dep.	= 82 m.	1,91381
So Rad	= $90^{\circ} 00'$	10,00000	So cof. Co.	= $56^{\circ} 15'$	9,74474
To dist.	= 98,62	1,99396	To diff. lat.	= 54 79	1,73870

BY GUNTER'S SCALE.

On the line of fine rhumbs, the extent from 5 points to 8 points or radius, will on the line of numbers reach from 82 to 99.

And the extent from 5 points to 3 points on the line of S. R. will reach from 82 to 55 on the line of numbers.

Or thus. The extent from 5 points in the fine rhumbs to 82 miles in the line of numbers, will reach from 8 points in the rhumbs to 99 in the numbers: And the same extent will reach from 3 points in the rhumbs to 55 in the numbers.

Lat. from	$47^{\circ} 30'$ N.
Diff. lat.	0 55 N.
Lat. in	$48^{\circ} 25'$ N.

690. CASE IV. Given the distance and difference of latitude:
Required the course and departure.

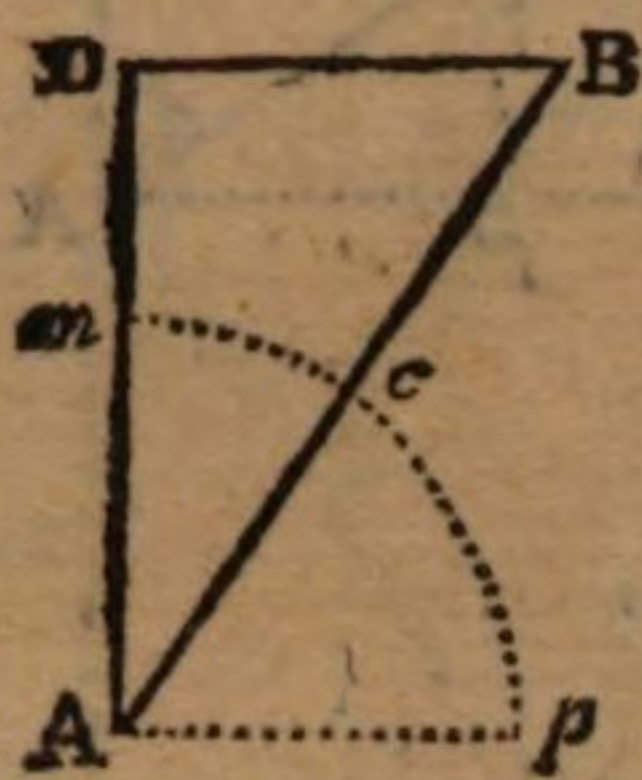
EXAM. *A ship from Lat. $47^{\circ} 20' N.$ sails between the north and east 98 miles, and is arrived in Lat. $48^{\circ} 42' N.$ What course did she steer, and what Dep. has she made?*

BY THE TRAVERSE TABLE. (712)

Seek in the table, till against the distance taken in its column, be found the given diff. lat. in one of the following columns; and adjoining to it stands the departure, which if less than the diff. lat. the course is found at the top of the column; but if greater, the course is found at bottom.

Now taking $47^{\circ} 20'$ from $48^{\circ} 42'$ leaves $1^{\circ} 22' = 82$ m. the diff. lat.

Then seeking till against dist. 98, stands lat. 82, the nearest will be lat. 81,95, and here the departure is 53,73 m. and the course is $33^{\circ} 15'$.



BY CONSTRUCTION.

- 1st. Describe the quadrant $A m c p$.
 - 2d. Continue $A m$, till $AD = 82$ m.
 - 3d. Thro' D draw DB parallel to $A p$.
 - 4th. On A with the distance 98 cut DB in B .
- Then the departure DB measures about 53 m.
And the course DAB is measured by the arc $m c$ of about 33° .

BY COMPUTATION.

To find the course.			To find the departure.		
As dist.	= 98 m.	8,00877	As Rad	= $90^{\circ} 00'$	10,00000
To Rad	= $90^{\circ} 00'$	10,00000	To dist.	= 98 m.	1,99123
So diff. lat.	= 82 m.	1,91381	So sin. Co.	= $33^{\circ} 13'$	9,73863
To cos. Co.	= $33^{\circ} 47'$	9,92258	To dep.	= 53,69	1,72986

BY GUNTER'S SCALE.

On the line of numbers, the extent from 98 m. to 82 m. will on the line of fines reach from 90, or radius, to about 57 deg.

And the extent on the line of fines, from 90° to 33° , will reach on the line of numbers from 98 m. to about 53 miles.

Or thus. The extent from 98 m. in the line of numbers, to 90° in the line of fines, will reach from 82 m. in the numbers to about 57° in the fines: And the same extent will reach from about 33° in the fines, to about 53 in the numbers.

So that the course is $N. 33^{\circ} 15' E.$ or $N. E. b. N.$ nearly.
And the departure is 53,69 miles to the Eastward.

691. CASE V. Given the distance and departure :
Required the course and difference of latitude.

EXAM. From the Lat. $50^{\circ} 13' N.$ a ship in sailing between the South and East 98 miles, makes her departure 82 miles: What course did she keep, and what Lat. is she arrived at?

BY THE TRAVERSE TABLE. (712)

Seek in the table, till against the distance taken in its column, be found the given departure in one of the following columns; and adjoining to it stands the diff. lat. which if greater than the departure, the course is found at the top of the column; but if less, the course is found at the bottom.

Now seeking till against the dist. 98 stands 82, the nearest will be 81,95, signed Dep. at bottom; and here the diff. lat. is 53,73 min. and the course is $56^{\circ} 45'$.

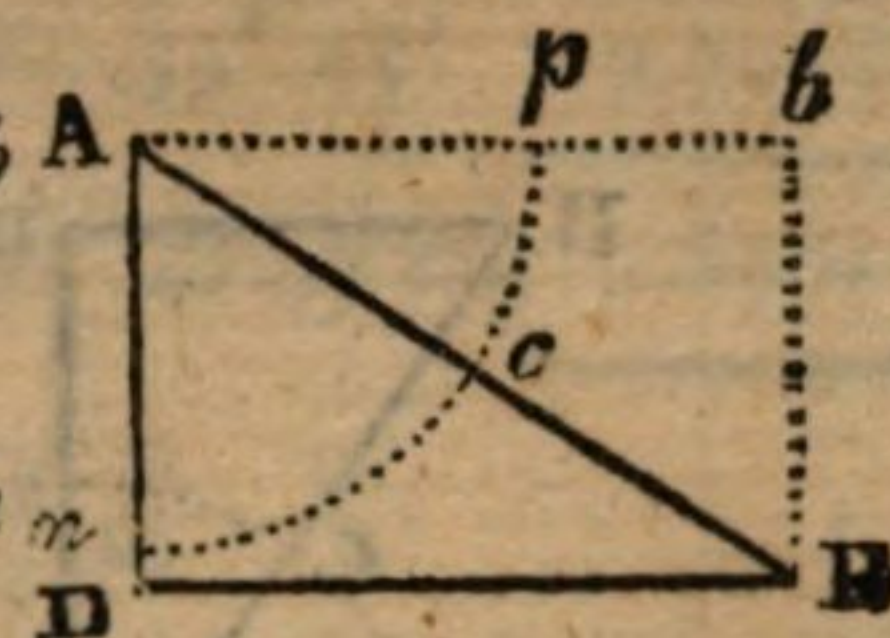
BY CONSTRUCTION.

1st. Describe the quadrant $Ancp$.

2d. Continue Ap , till $Ab = 82$ m.; and thro' b draw bB parallel to An .

3d. From A with the dist. 98 m. cut bB in B .

4th. Thro' B draw BD parallel to Ab , meeting An continued, in D .



Then the diff. lat. AD measures about 53 miles.

And the course DAB is measured by the arc nc of about 57° .

BY COMPUTATION.

To find the Course.			To find the diff. lat.		
As dist.	= 98 m.	8,00877	As Rad	= $90^{\circ} 00'$	10,00000
To Rad	= $90^{\circ} 00'$	10,00000	To dist.	= 98 m.	1,99123
So dep.	= 82 m.	1,91381	So cos. Cou.	= $56^{\circ} 47'$	9,73863
To fin. Cou.	= $56^{\circ} 47'$	9,92258	To diff. lat.	= 53,69	1,72986

Then $50^{\circ} 13' N. - 0^{\circ} 54' N. = 49^{\circ} 19' N.$ For 53,69 m. is nearest 54.

BY GUNTER'S SCALE.

On the line of numbers, the extent from 98 m. to 82 m. will on the line of fines reach from 90° , or radius, to about 57° deg.

And the extent on the line of fines, from 90° to 33° , will reach from 98 m. to about 53 m. on the line of numbers.

Or thus. The extent from 98 m. in the line of numbers to 90° in the line of fines, will reach from 82 m. in the numbers to about 57° in the fines: And the same extent will reach from about 33° in the fines, to about 53 m. in the numbers.

So that the Course is $S. 56^{\circ} 47' E.$ or $S. E. b. E.$ nearly.

And the latitude arrived in is $49^{\circ} 19' N.$

692. CASE VI. Given the difference of latitude and departure:
Required the course and distance.

EXAM. *A ship from Lat. $48^{\circ} 32' N.$ is arrived in Lat. $49^{\circ} 54' N.$ and is got 54 miles to the westward of her departed meridian: What course did she steer, and what is the direct distance she has run?*

BY THE TRAVERSE TABLE. (712)

Seek in the table till the given diff. lat. and departure are found together in their respective columns; then right against them will be found the distance in its column, and the course stands among the degrees at the top or bottom of the column, where the diff. lat. and depart. were found.

Now taking $48^{\circ} 32'$ from $49^{\circ} 54'$, leaves $1^{\circ} 22' = 82$ m. the diff. lat.

Then in the table it will be found, that the numbers standing together, the nearest to 82 and 54, are 81,95 and 53,73; the distance answering to these is 98 m. and the course is $33^{\circ} 15'$.

BY CONSTRUCTION.



1st. Describe the quadrant $A m c p$, and continue $A m$ till $AD = 82$ m.

2d. Thro' D draw DB parallel to $A p$, and equal to 54 miles, and draw AB .

Then the distance AB measures about 98 miles.

And the course DAB is measured by the arc mc of about 33° .

BY COMPUTATION.

To find the Course.			To find the distance.		
As diff. lat.	$= 82$ m.	8,08619	As sin. Cou.	$= 33^{\circ} 22'$	0,25964
To depart.	$= 54$ m.	1,73239	To dep.	$= 54$ m.	1,73239
So Rad	$= 45^{\circ} 00'$	10,00000	So Rad	$= 90^{\circ} 00'$	10,00000
To tan. Cou.		$= 33 \ 22$	To dist.		$= 98,18$
		9,81858			1,99203

BY GUNTER'S SCALE.

On the line of numbers, the extent from 82 m. to 54 m. will reach on the line of tangents from 45° to about 33° .

And the extent on the line of fines, from about 33° to 90° , will reach on the line of numbers from 54 m. to about 98 m.

Or thus. The extent from 82 in the line of numbers to 45° in the line of tangents, will reach from 54 in the line of numbers, to about 33° in the line of tangents.

Also, the extent from about 33° in the fines to 54 in the numbers, will reach from 90° in the fines to about 98 m. in the numbers.

So the Course is $N. 33^{\circ} 22' W.$ or $N. W. b. N.$ nearly.

And the distance is 98,18 miles.

693.

Questions to exercise the foregoing cases.

QUEST. I. Four days ago we were in Lat. $3^{\circ} 25' S.$; and have since that time run on a direct course NW. by N. at the rate of 8 miles an hour: Required our present latitude and departure?

One day = 24 hours: Then $24 \times 4 = 96$ hours.

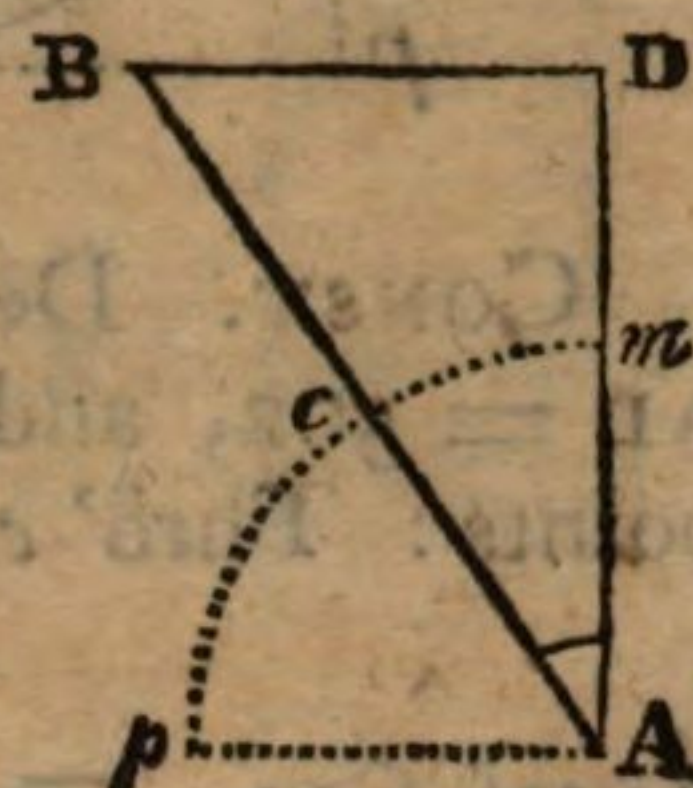
And $96 \times 8 = 768$ miles, the whole distance.

CONSTRUCTION.

1st. Draw the meridian AD, and describe the quadrant A m p.

2d. Lay off the course 3 points from m to c, and draw the rhumb line AB.

3d. On the rhumb line lay the distance from A to B, and draw BD parallel to p A.



COMPUTATION.

As Rad	=	$90^{\circ} 00'$	10,00000
To dist.	=	768 m.	2,88536
So cof. Cou.	=	$33^{\circ} 45'$	9,91985
To diff. lat.	=	638,6 m.	2,80521

As Rad	=	$90^{\circ} 00'$	10,00000
To dist.	=	768 m.	2,88536
So fin. Cou.	=	$33^{\circ} 45'$	9,74474
To dep.	=	426,7 m.	2,63010

Now 6,0)63,9($10^{\circ} 39$.

Then Lat. from $3^{\circ} 25' S.$
diff. lat. $10 39 N.$

Answer { Lat. in $7 14 N.$
Depart. 426,7 miles.

QUEST. II. Yesterday noon we were in Lat. $38^{\circ} 32' N.$ and this day at noon we are in Lat. $36^{\circ} 56' N.$; we have run on a direct course between the S. and E. $5\frac{1}{2}$ knots an hour: Required our course and departure?

Lat from $38^{\circ} 32' N.$

Lat. in $36 56 N.$

Diff. lat. $1 36 = 96$ m.

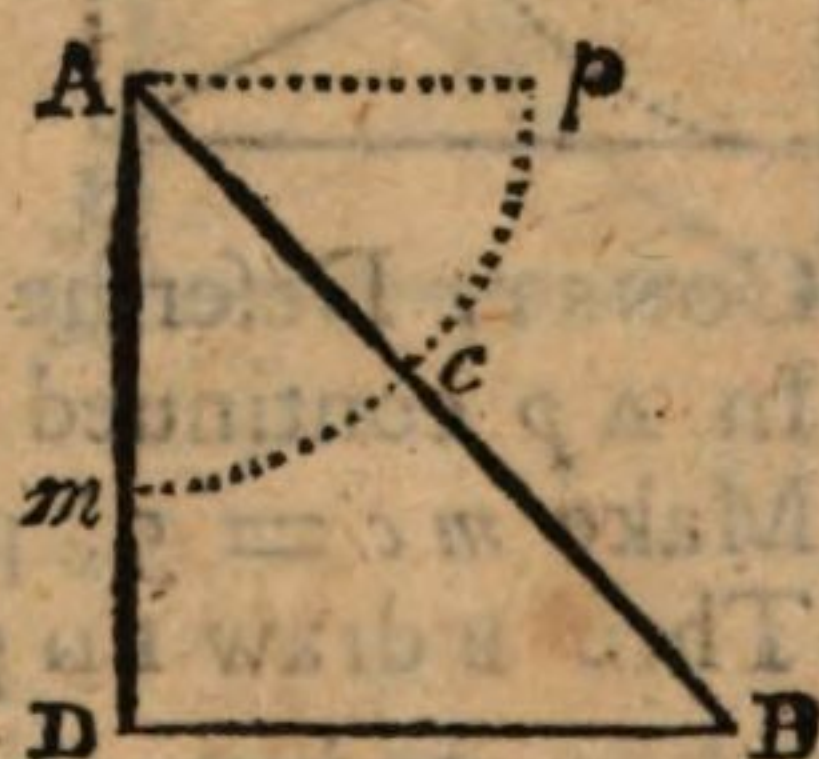
24 hours.

$5,5 = 5\frac{1}{2}$

120

120

Diff. = 132,0 m.



CONST. Describe the quadrant A m p; draw the meridian AD = 96, and draw DB parallel to Ap; with 132 m. from A, cut DB in B.

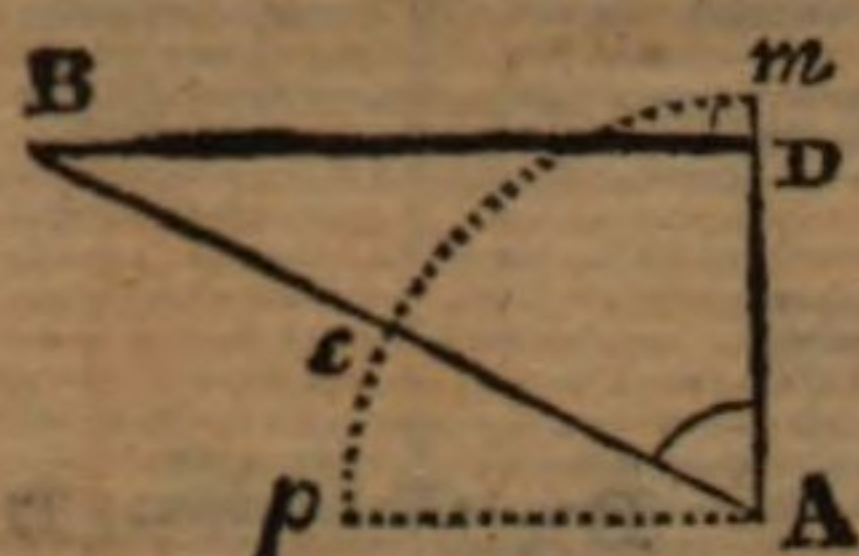
COMPUTATION.

As dist.	=	132 m.	7,87943
To Rad	=	$90^{\circ} 00'$	10,00000
So diff. lat.	=	96 m.	1,98227
To cof. Cou.	=	$43^{\circ} 20'$	9,86170

As Rad	=	$90^{\circ} 00'$	10,00000
To dist.	=	132 m.	2,12057
So fin. Cou.	=	$43^{\circ} 20'$	9,83648
To dep.	=	90,58	1,95705

Answer { Course is S. $43^{\circ} 20'$ E. or SE. b. S. $\frac{3}{4}$ E. nearly.
Departure 90,58 miles to Eastward.

QUEST. III. A ship in Lat. $3^{\circ} 52' S.$ is bound to a port bearing NW. by W. $\frac{1}{2}$ W. in Lat. $4^{\circ} 30' N.$: How far does that port lie to the westward, and what is the ship's distance from it?



Lat. from $3^{\circ} 52' S.$
Lat. to $4^{\circ} 30' N.$

Diff. lat. $8^{\circ} 22'$
 60

502 miles.

CONST. Describe the quadrant A m p: Draw the meridian AD = 502, and thro' D draw DB parallel to A p: Make $mc = 5\frac{1}{2}$ points: Thro' c draw AB meeting DB in B.

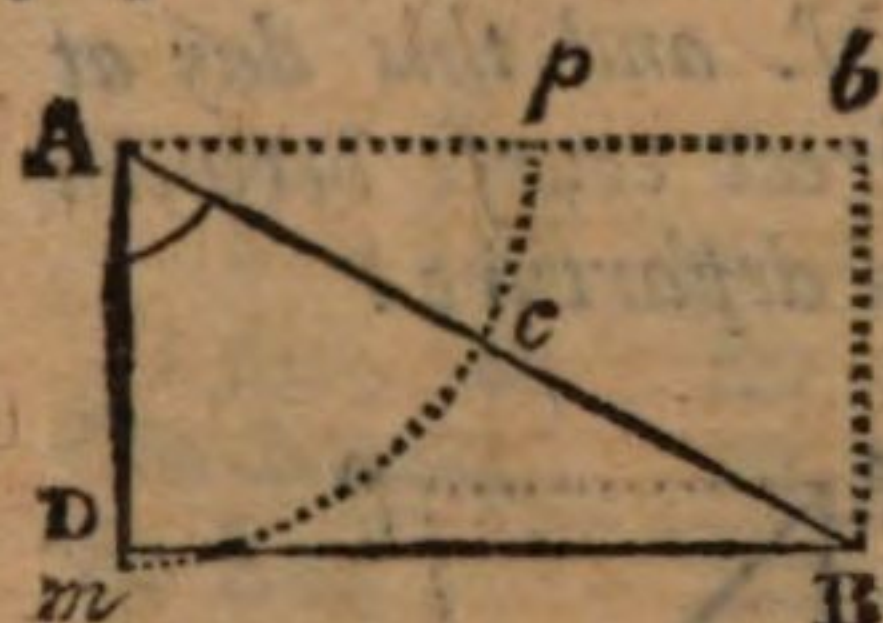
COMPUTATION.

As cos. Cou. = $61^{\circ} 52'$ 0,32650
To diff. lat. = 502 m. 2,70070
So Rad = $90^{\circ} 00'$ 10,00000
To dist. = 1065 3,02720

As cos. Cou. = $61^{\circ} 52'$ 0,32650
To diff. lat. = 502 m. 2,70070
So sin. Cou. = $61^{\circ} 52'$ 9,94540
To dep. = 938,9 2,97260

Answer { The port lies 938,9 m. to the westward.
The direct distance is 1065.

QUEST. IV. A ship from Lat. $30^{\circ} 14' N.$ sails SE. by E. $\frac{1}{2}$ E.; and four days after meets a sloop who had sailed directly east at the rate of 6 miles an hour, she having been four days before under the meridian the ship departed from: Required the difference of their rate of sailing, and their present latitude?



As the ship and sloop sailed from the same meridian, and the sloop runs directly east; therefore her distance will be the ship's departure.

Now in 4 days are 96 hours.

And $96 \times 6 = 576$ miles of dep.

CONST. Describe the quadrant A m p.

In A p continued take A b = 576, and draw b B parallel to A m.

Make $mc = 5\frac{1}{2}$ points, and thro' c draw A c meeting b B in B.

Thro' B draw BD parallel to b A meeting A m continued in D.

COMPUTATION.

As sin. Cou. = $61^{\circ} 52'$ 0,05460
To dep. = 576 m. 2,76042
So Rad = $90^{\circ} 00'$ 10,00000
To dist. = 653,2 m. 2,81502

As sin. Cou. = $61^{\circ} 52'$ 0,05460
To dep. = 576 m. 2,76042
So cos. Cou. = $61^{\circ} 52'$ 9,67350

To diff. lat. = 308 m. 2,48852

Now $96)653,2(6,8$ m. per hour the
[ship's rate.

And $6,0)30,8(5$ Then Lat. fr. $30^{\circ} 14' N.$
diff. lat. $5^{\circ} 08' S.$

772

5 8

Lat. in $25^{\circ} 06' N.$

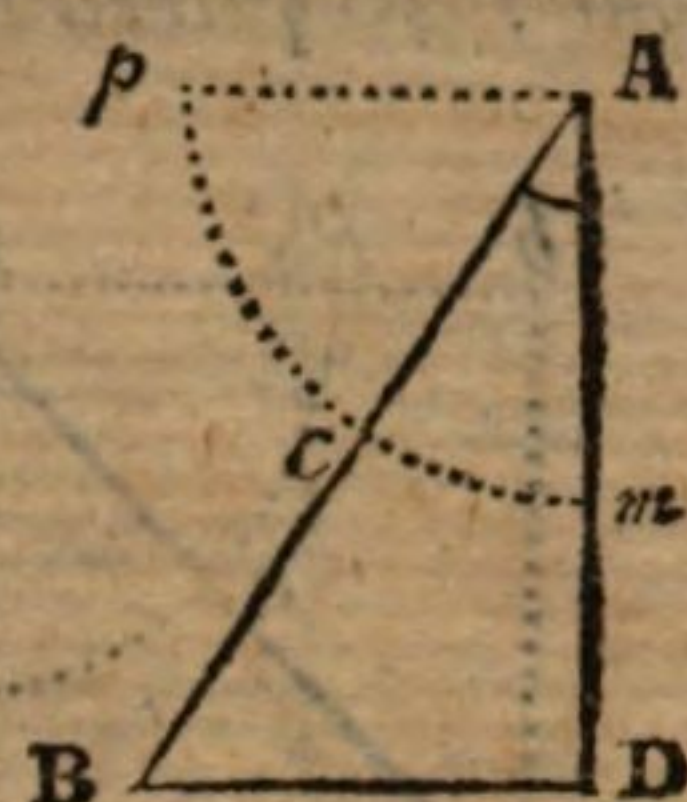
So the difference of their rate of sailing is $\frac{8}{10}$ or $\frac{4}{5}$ of a mile per hour.

QUEST.

QUEST. V. *A ship from the Lat. $48^{\circ} 17' N.$ sails SW. by S. until she has depressed the north pole two degrees: What direct distance has she run, and how many miles is she got to the westward?*

To depress the pole two degrees, the ship must sail southward until her diff. lat. is 2 degrees, or 120 miles.

CONST. 1st. Draw $AD = \text{diff. lat. } 120 \text{ m.}$
 2d. Describe the quadrant Amp , make $mc = 3$ points.
 3d. Thro' c draw AB , meeting DB drawn thro' D parallel to Ap .



COMPUTATION.

As cos. Cou.	= $33^{\circ} 45'$	0,08015	As cos. Cou.	= $33^{\circ} 45'$	0,08015
To diff. lat.	= 120 m.	2,07918	To diff. lat.	= 120 m.	2,07918
So Rad	= $90^{\circ} 00'$	10,00000	So sin. Cou.	= $33^{\circ} 45'$	9,74474
To dist.	= 144,3	2,15933	To dep.	= 80,18	1,90407

Answer { Ship has run 144,3 miles.
 And has got to the westward 80,18 miles.

QUEST. VI. *Two ports lie under the same meridian, one in latitude $52^{\circ} 30' N.$ and the other in latitude $47^{\circ} 10' N.$ A ship from the southernmost sails due East 9 knots an hour, and two days after meets a sloop that had sailed from the Northernmost port: Required the sloop's direct course and distance run?*

Here the distance the ship sails East is the sloop's departure.

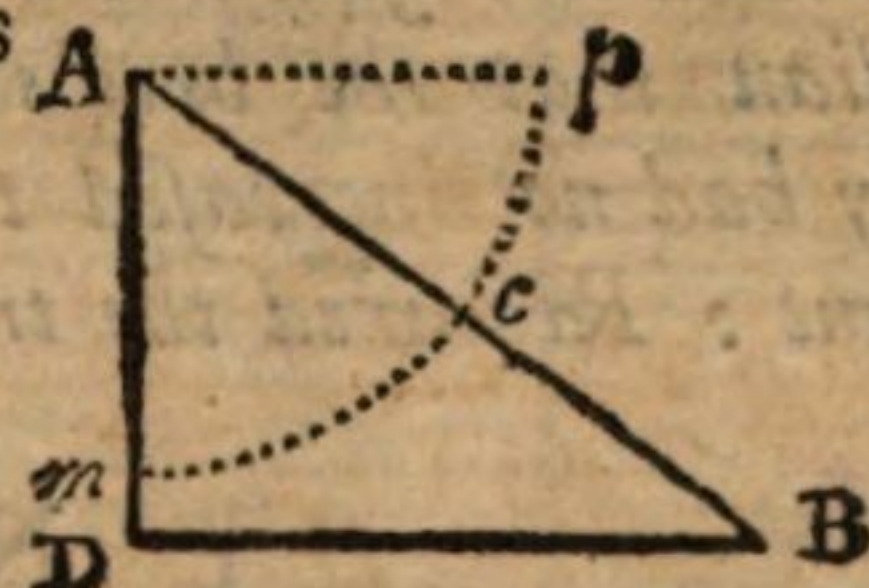
Now 2 days = 48 hours.

Then $48 \times 9 = 432 \text{ m.} = \text{departure.}$

Sloop's lat. $52^{\circ} 30' N.$

Ship's lat. $47^{\circ} 10' N.$

Diff. lat. $5^{\circ} 20' = 320 \text{ m.}$



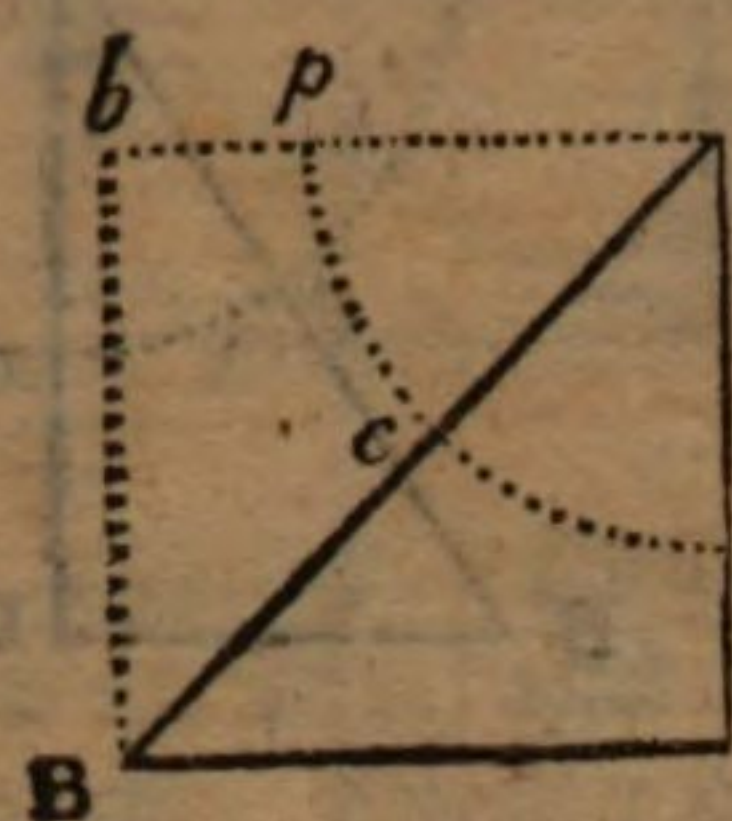
CONST. In the meridian, take AD for the diff. lat. 320 m. and perpendicular to AD draw the departure $DB = 432 \text{ m.}$ and draw the distance AB .

COMPUTATION.

As diff. lat.	= 320 m.	7,49485	As sin. Cou.	= $53^{\circ} 28'$	0,09501
To dep.	= 432 m.	2,63548	To dep.	= 432 m.	2,63548
So Rad	= $45^{\circ} 00'$	10,00000	So Rad	= $90^{\circ} 00'$	10,00000
To tan. Cou.	= $53^{\circ} 28'$	10,13033	To dist.	= 537,6	2,73049

Answer { The sloop has sailed S. $53^{\circ} 28' E.$ or SE. $\frac{3}{4} E.$
 And has run 537,6 miles.

QUEST. VII. *A ship from a port in latitude $38^{\circ} 25' S.$ sails between the S. and W. at the rate of $7\frac{1}{2}$ knots an hour; three days after meets a sloop, who two days before had sailed from a port under the same meridian the ship departed from, and kept on a west course 8 miles an hour: Required the ship's direct course and present latitude?*



Now 3 days is 72 hours, which at $7\frac{1}{2}$ knots an hour, makes 540 miles for the ship's run.

And 2 days is 48 hours, which, at 8 knots an hour, makes 384 miles for the sloop's run, and is equal to the westing, or departure of the ship.

CONST. Having described the quadrant A m p, make $A b = 384$; from A, with 540, cut b B parallel to AD, in B; draw AB, and BD parallel to A p.

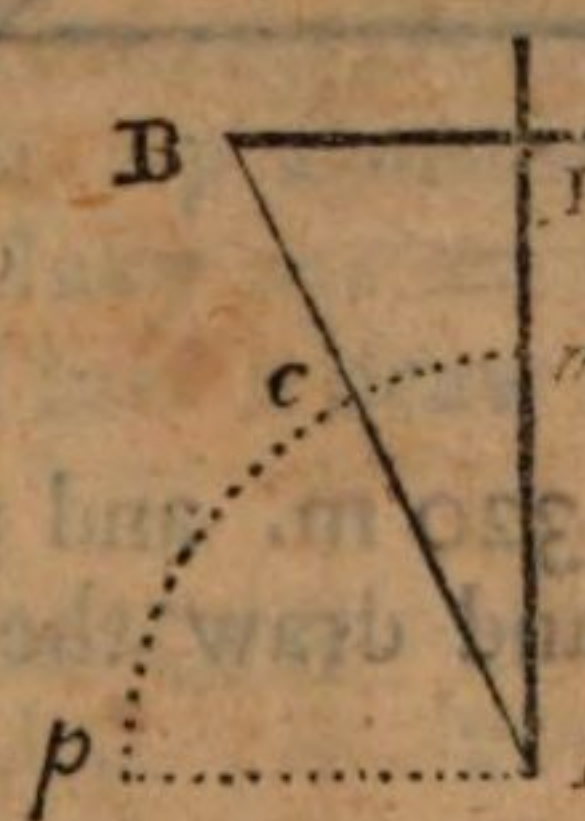
COMPUTATION.

As Diff.	= 540 m.	7,26761	As Rad	= $90^{\circ} 00'$	10,00000
To Rad	= $90^{\circ} 00'$	10,00000	To Diff.	= 540 m.	2,73239
So Dep.	= 384 m.	2,58433	So cof. Cou.	= $45^{\circ} 20'$	9,84694
To fin. Cou.	= $45^{\circ} 20'$	9,85194	To diff. lat.	= 379,6	2,57933

6,0)38,0($6^{\circ} 20'$.

And $(38^{\circ} 25' + 6^{\circ} 20' =) 44^{\circ} 45' S.$ Answer { Course S. $45^{\circ} 20' W.$ or SW.
Present latitude is $44^{\circ} 45' S.$

QUEST. VIII. *A brig from a port in latitude $28^{\circ} 38' N.$ sails due N. at the rate of $8\frac{1}{2}$ knots an hour; after three days she meets a ship who had run due W. 342 miles from a port 30 leagues to the eastward of the meridian that the brig's crew thought themselves under; who also found, they had not increased their latitude by 24 leagues so much as by their account: Required the true course and distance the brig has made?*



Now $8\frac{1}{2}$ knots an hour for 3 days, is 612 miles, for the brig's apparent northing; from which taking 24 leagues, or 72 m. her error in account, leaves 540 miles for her true diff. lat.

And as the ship's departed meridian is 30 leagues, or 90 miles to the eastward of the brig's; then this taken from 342 leaves 252 m. for the westing from the brig's meridian.

So that the brig having made 540 m. northing, and 252 m. westing; her course and distance, found by the 6th case (692), will be

Course N. $25^{\circ} 01' W.$ or NNW. $\frac{1}{4} W.$ nearly.

Distance 595,9 miles.

PLANE CHART

Pl: II.



F. Jefferys sculp.

10. 11

BOGNETIA



11. 12

SECTION V.

Of compound courses.

694. A COMPOUND COURSE is an irregular track which a ship makes in a known time, by sailing on several different courses: Or where two or more cases of Plane sailing are concerned.

A TRAVERSE is a Compound course, wherein several different successive courses and distances are known.

695. TO WORK A TRAVERSE,
Or, to reduce a compound course to a single one.

1st. Make a table of six columns, title them Course, Dist. N. S. E. W. beginning at the left side, and write the given courses and distances in their respective columns.

2d. In the traverse table (711, 712) seek the given courses and distances, and let the corresponding differences of latitude and departures be wrote in their proper columns in the table made for the question.

3d. Add up the columns of northing, southing, easting, and westing; then the difference between the sums of the northing and southing gives the whole difference of latitude of the same name with the greater; and the difference between the sums of the easting and westing will be the whole departure, of the same name with the greater.

4th. The whole diff. lat. and departure to the compound course being found, the direct course and distance will be found as in Case VI. of single courses.

696. TO CONSTRUCT A TRAVERSE.

1st. Describe a circle with the chord of 60 degrees, and divide it into 4 quadrants; marking the north point with N.

2d. Lay off each course on the circumference, reckoned from its proper meridian; and from the centre to each point draw so many blank radii; mark these with the proper number of the course.

3d. On the first radius, lay the first distance, mark its extremity; through this extremity, and parallel to the second radius, draw the second distance of its proper length; through the extremity of the second distance, and parallel to the third radius, draw the third distance of its proper length: And thus proceed until all the distances are drawn.

4th. A

4th. A line drawn from the extremity of the last distance, to the centre of the circle, will represent the distance made good; and a line drawn from the same point, perpendicular to the meridian (lengthened if necessary), will represent the departure.

697. When a ship from a given place is bound to a known port; and on some occasion she is obliged to run on one or more different courses, not in the direct one to the port; and then wants to find the direct course and distance she must now run to gain her port, observe the following precepts.

1st. Find the diff. lat. and dep. between the ship's first place and the port bound to.

2d. Find the diff. lat. and dep. between the ship's first place and the place she is come to.

3d. If these differences of latitude are both of the same name, take their difference for a new diff. lat.: But if of contrary names, take their sum.

4th. If the departures are both of the same name, take their difference for a new departure: But take their sum if of contrary names.

5th. To this new difference of latitude and departure, find the course and distance (692).

6th. If between the place sailed from and the place come to, there has been more than one course: To each course let the diff. lat. and departure be found; and let their sum or difference be taken according as they are of the same, or of contrary names; and this will give the diff. lat. and departure between the place sailed from and the place come to: Then proceed by the 3d, 4th and 5th precepts.

698. TO CONSTRUCT A COMPOUND COURSE.

1st. Describe a circle, in which draw the meridian and parallel of the place sailed from.

2d. Construct the triangle between the place sailed from, marked A, and the place bound to, marked B; and let the intersection of the diff. lat. and departure be marked D.

3d. Construct the figure between the place sailed from, or A, and the place come to, marked C; and let the intersection of this diff. lat. and departure be marked E.

4th. Through C draw CF parallel to AD, meeting BD, continued, if necessary, in F; and draw CB.

5th. Then in the triangle CFB, the lines CF, FB, CB, will represent the diff. lat. departure and distance between the place come to, and the place bound to.

6th. From the centre A draw a line parallel to CB, in the direction from C to B, and this shews the course wanted.

699. *Examples to exercise Traverse sailing.*

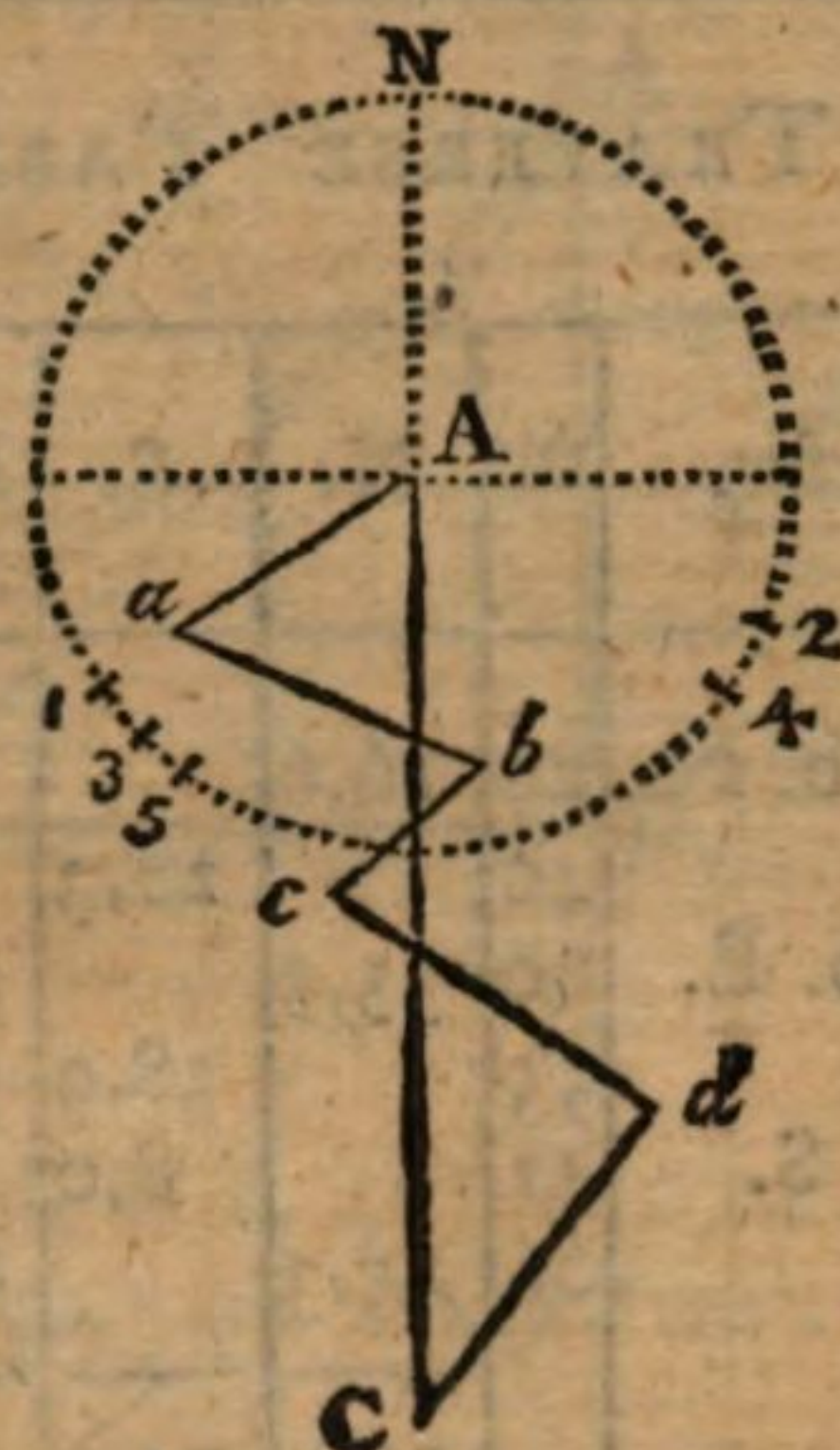
QUESTION I. *A ship sails from a place in latitude $24^{\circ} 32' N.$ and has run the following courses and distances, viz.*

1st. SW. b. W. dist. 45 m. 2d. ESE. dist. 50 m. 3d. SW. dist. 30 m.
4th. SE. b. E. dist. 60 m. 5th. SW. b. S. $\frac{1}{4}$ W. dist. 63 m.

Required her present latitude, with the direct course and distance between the place sailed from, and the place come to?

Construct the traverse table by art. 695, and the figure by art. 696.

TRAVERSE TABLE.					
Courses.	Dist	N.	S.	E.	W.
SW. b. W.	45		25,0		37,4
ESE.	50		19,1	46,2	
SW.	30		21,2		21,2
SE. b. E.	60		33,3	49,9	
SW. b. S. $\frac{1}{4}$ W.	63		50,6		37,5
			149,2	96,1	96,1



The traverse table being completed; the sum of the southings is 149,2 miles, and so far the ship has got to the southward, or altered her latitude.

Now 149 miles is $2^{\circ} 29'$
Then Lat. from $24^{\circ} 32' N.$
Diff. lat. $2^{\circ} 29' S.$
Present lat. $22^{\circ} 03' N.$

The miles of departure in the east column are 96,1; and those in the west column are also 96,1: But as the east and west departures are directly opposite, they destroy one another, and the ship in her present station has made no departure; therefore she is under the same meridian sailed from: Consequently her course made good is directly south; and her distance is the same as the difference of latitude, which is 149,2.

In this figure, the circle which is described with the chord of 60° , represents the horizon, the centre whereof is the place the ship sailed from; thro' which are drawn the two diameters at right angles to one another, the one representing the meridian, the other the parallel of latitude the ship departed from: On the circumference is laid the several courses, and numbered 1, 2, 3, 4, 5. On the first rhumb A 1, is laid the first distance $Aa = 45$; thro' a , and parallel to the rhumb A 2, is drawn the second distance $ab = 50$; thro' b , and parallel to the rhumb A 3, is drawn the third distance $bc = 30$; thro' c , and parallel to the rhumb A 4, is drawn the fourth distance $cd = 60$; thro' d , and parallel to the rhumb A 5, is drawn the fifth distance $de = 63$.

QUEST.

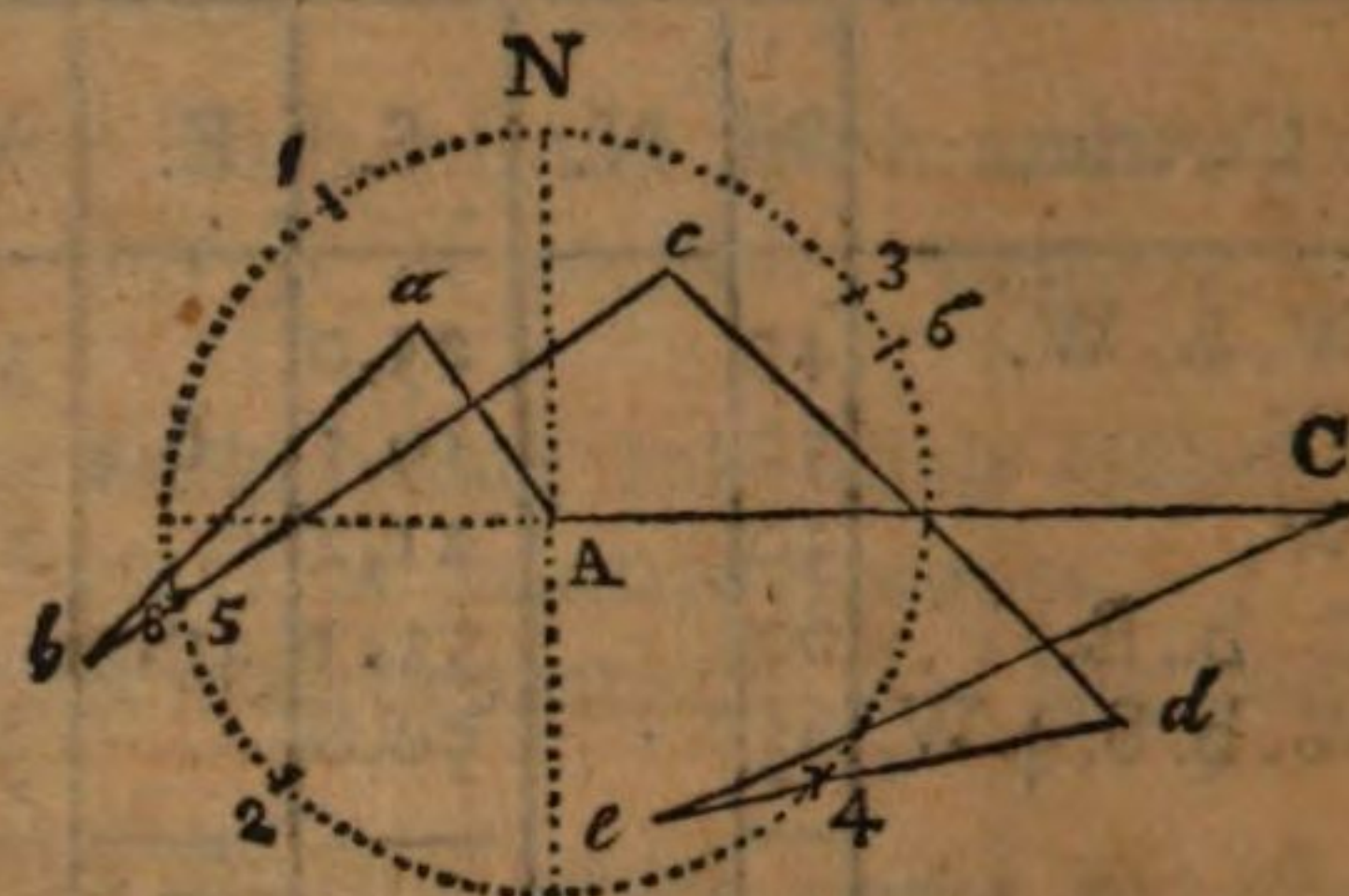
QUEST. II. *A ship from the latitude $28^{\circ} 32' N$. has run the following courses, viz.*

1st. NW. b. N. dist. 20 m. 2d. SW. dist. 40 m. 3d. NE. b. E. dist. 60 m.
4th. SE. dist. 55 m. 5th. W. b. S. dist. 41 m. 6th. E. NE. dist. 66 m.

Required her present latitude, with the direct course and distance between the place sailed from and the place come to?

Construct the traverse table by art. 695, and the figure by art. 696.

TRAVERSE TABLE.					
Courses.	Dif.	N.	S.	E.	W.
NW. b. N.	20	16,6			11,1
SW.	40		28,3		28,3
NE. b. E.	60	33,3		49,9	
SE.	55		38,9	38,9	
W. b. S.	41		8,0		40,2
ENE.	66	25,3		61,0	
		75,2	75,2	149,8	79,6
				79,6	
				70,2	Dep.



The traverse table being filled up, the sum of the northings and southings are both 75,2 miles; which being of contrary directions, shew that the ship has returned to the same parallel of latitude sailed from.

The sum of the eastings is 149,8, and that of the westings is 79,6; their difference 70,2 shews that the ship has gained so much to the eastward, that being greatest.

Consequently the course made good is due East.

And the distance is 70,2 miles.

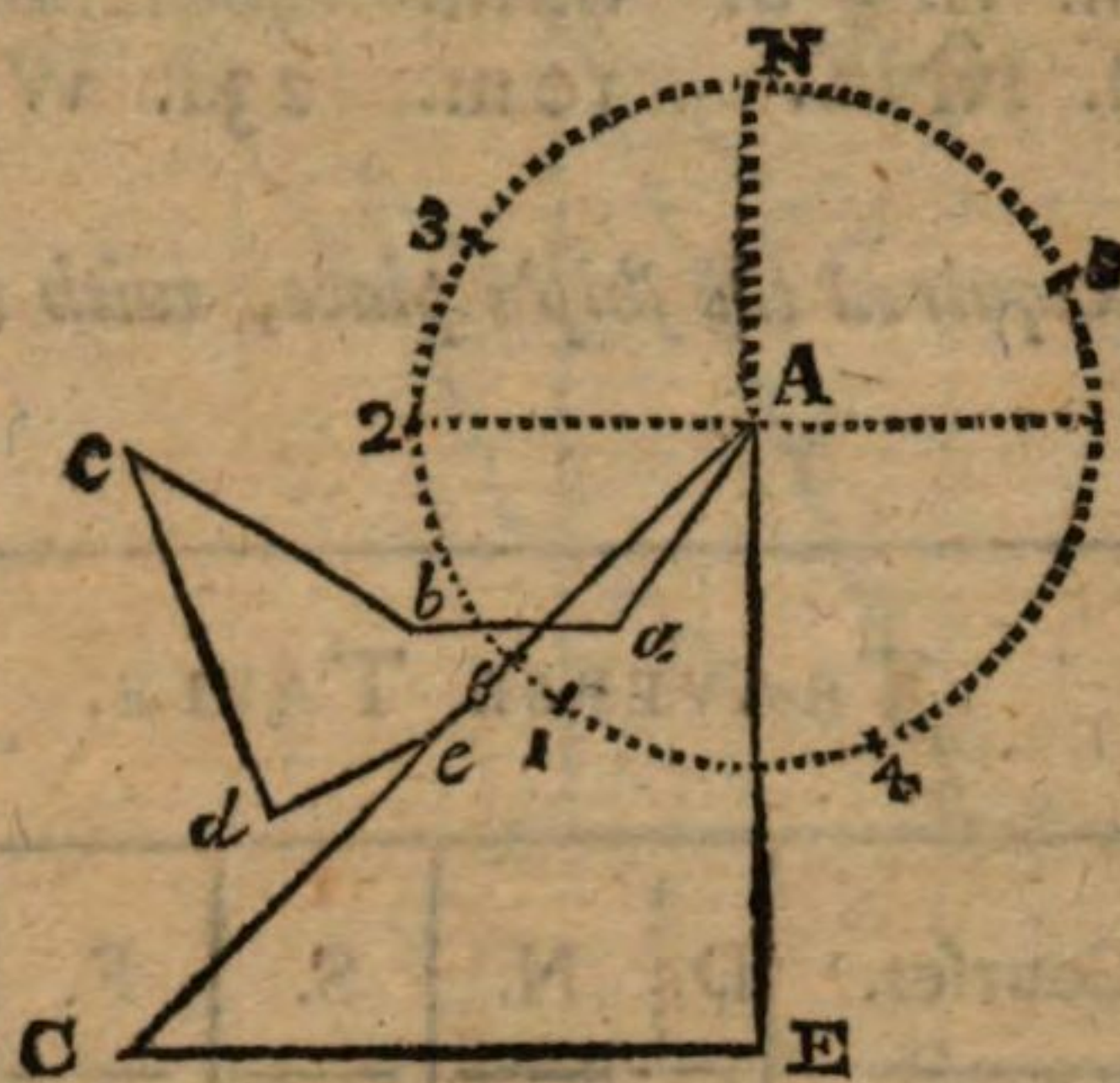
Here A is the place sailed from; and c is the place the ship is come to, by sailing along the lines Aa, ab, bc, cd, de, ec.

The distance she has got from A, is represented by Ac; which also expresses the rhumb between A and c.

QUEST.

QUEST. III. Since yesterday noon we have run the following courses :
 1st. SW. b. S. 20 m. 2d. W. 16 m. 3d. NW. b. W. 28 m.
 4th. SSE. 32 m. 5th. ENE. 14 m. 6th. SW. 36 m.
 What diff. lat. and departure has the ship made, and what is her direct
 course and distance ?

TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
SW. b. S.	20		16,6		11,1
W.	16				16,0
NW. b. W.	28	15,6			23,3
SSE.	32		29,6	12,3	
ENE.	14	5,4		12,9	
SW.	36		25,5		25,5
		21,0	71,7	25,2	75,9
			21,0		25,2
		D.lat.	50,7	Dep.	50,7

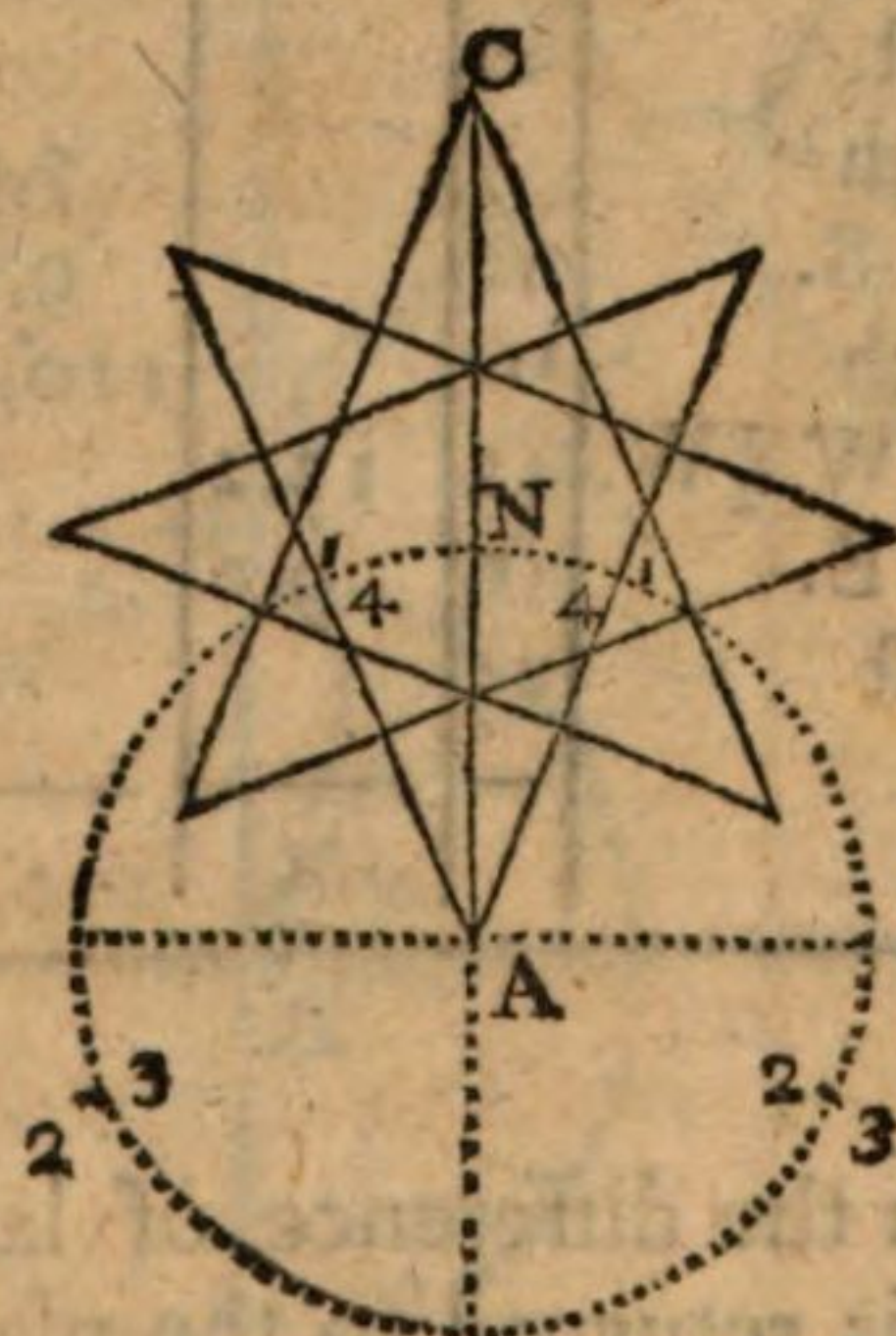


As the D. lat. and Dep. are equal, the course is S. 45° W. or SW.
 And, As $f.\angle A : CE :: f.\angle E : AC$. Or $f.45^{\circ}00' : 50,7 \text{ m.} :: f.90^{\circ}00' : 71,7 \text{ m.}$

QUEST. IV. Two ships, A and B, part company in lat. $31^{\circ}31' \text{ N.}$ and
 meet together again at the end of two days, having run as follows :
 A. 1st. NNE. 96 m. 2d. WSW. 96 m. 3d. ESE. 96 m. 4th. NNW. 96 m.
 B. 1st. NNW. 96 m. 2d. ESE. 96 m. 3d. WSW. 96 m. 4th. NNE. 96 m.
 Required the lat. arrived in, with the direct course and dist. of each ship ?

As the courses steered by both ships are equally distant from the
 meridian ; therefore one traverse will serve for both.

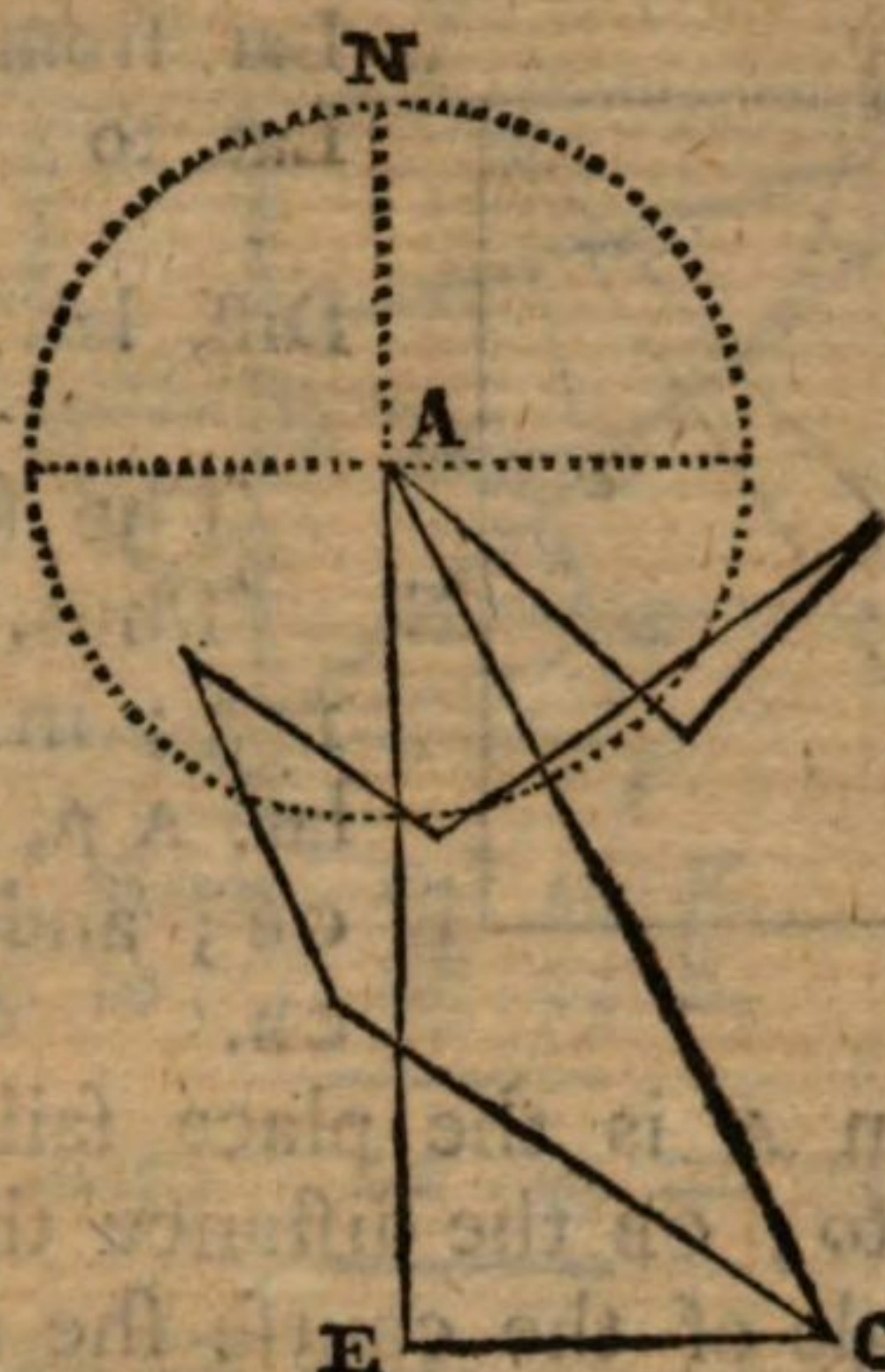
TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
NNE.	96	88,7		36,7	
WSW.	96		36,7		88,7
ESE.	96		36,7	88,7	
NNW.	96	88,7			36,7
		177,4	73,4	125,4	125,4
		73,4			
		104,0	D.lat.		



There being no departure, and the diff. lat. being N.
 Therefore the course made good is N. and the distance is 104 miles.
 The lat. arrived in is $33^{\circ}15' \text{ N.}$

QUEST. VI. The last 24 hours we have run the following courses, viz.
 1st. SE. 40 m. 2d. NE. 28 m. 3d. SW. b. W. 52 m.
 4th. NW. b. W. 30 m. 5th. SSE. 36 m. 6th. SE. b. E. 58 m.
 Required the present latitude, departure, direct course and distance?

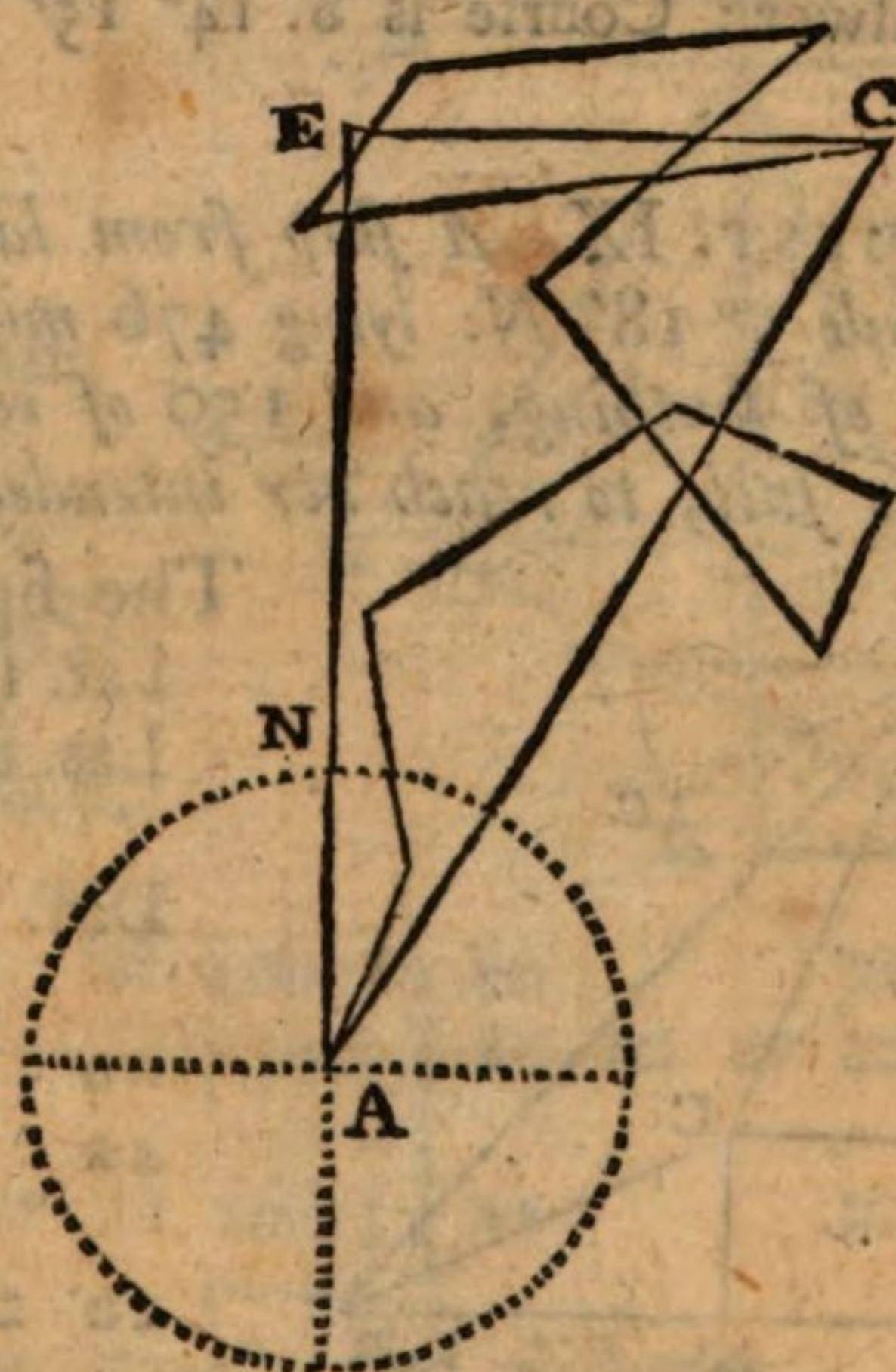
TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
SE.	40		28,3	28,3	
NE.	28	19,8		19,8	
SW. b. W.	52		28,9		43,2
NW. b. W.	30	16,7			24,9
SSE.	36		33,3	13,8	
SE. b. E.	58		32,2	48,2	
		36,5	122,7	110,1	68,1
			36,5	68,1	
		D.lat	86,2	42,0	Dep



For the course. As 86,2 m. : 42 m. :: Rad : t. $25^{\circ} 59'$. Or SSE. $\frac{1}{4}$ E. nearly.
 For the distance. As f. $25^{\circ} 59'$: 42 m. :: Rad : 95,87 m.

QUEST. VII. Yesterday noon we were in lat. $3^{\circ} 18' S$. and since then we have plied on the following courses, viz.
 1st. NNE. 22 m. 2d. N. b. W. 30 m. 3d. NE. b. E. 40 m.
 4th. ESE. 25 m. 5th. SSW. 18 m. 6th. NW. b. N. $\frac{1}{2}$ W. 50 m.
 7th. NE. $\frac{1}{2}$ E. 42 m. 8th. W. b. S. $\frac{1}{2}$ W. 45 m. 9th. SW. b. S. 20 m.
 10th. E. b. N. $\frac{1}{4}$ E. 62 m. Required our present lat. and departure, with the course and distance made good?

TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
NNE.	22	20,3		8,4	
N. b. W.	30	29,4			5,8
NE. b. E.	40	22,2		33,3	
ESE.	25		9,6	23,1	
SSW.	18		16,6		6,8
NW. b. N. $\frac{1}{2}$ W.	50	38,6			31,7
NE. $\frac{1}{2}$ E.	42	26,6		32,5	
W. b. S. $\frac{1}{2}$ W.	45		4,4		44,8
SW. b. S.	20		16,6		11,1
E. b. N. $\frac{1}{4}$ E.	62	9,1		61,3	
		146,2	47,2	158,6	100,2
			47,2	100,2	
		99,0	D.lat	58,4	Dep



For the course. As 99 m. : 58,4 m. :: Rad : t. $30^{\circ} 32'$. Or NNE. $\frac{3}{4}$ E.
 For the dist. As f. $30^{\circ} 32'$: 58,4 m. :: Rad : 115 the distance.

QUEST. X. *Four days ago we were in lat. $4^{\circ} 39'$ S. long. $83^{\circ} 16'$ E. of London; and now we are in lat. $0^{\circ} 35'$ N. having made 200 miles of westing: Required our present course and distance to Achen in the Island of Sumatra?*

The fig. is constructed by art. 698.

Lat. from $4^{\circ} 39'$ S.
Lat. to $5 \ 15$ N.

Diff. lat. $9 \ 54 = 594$ miles.

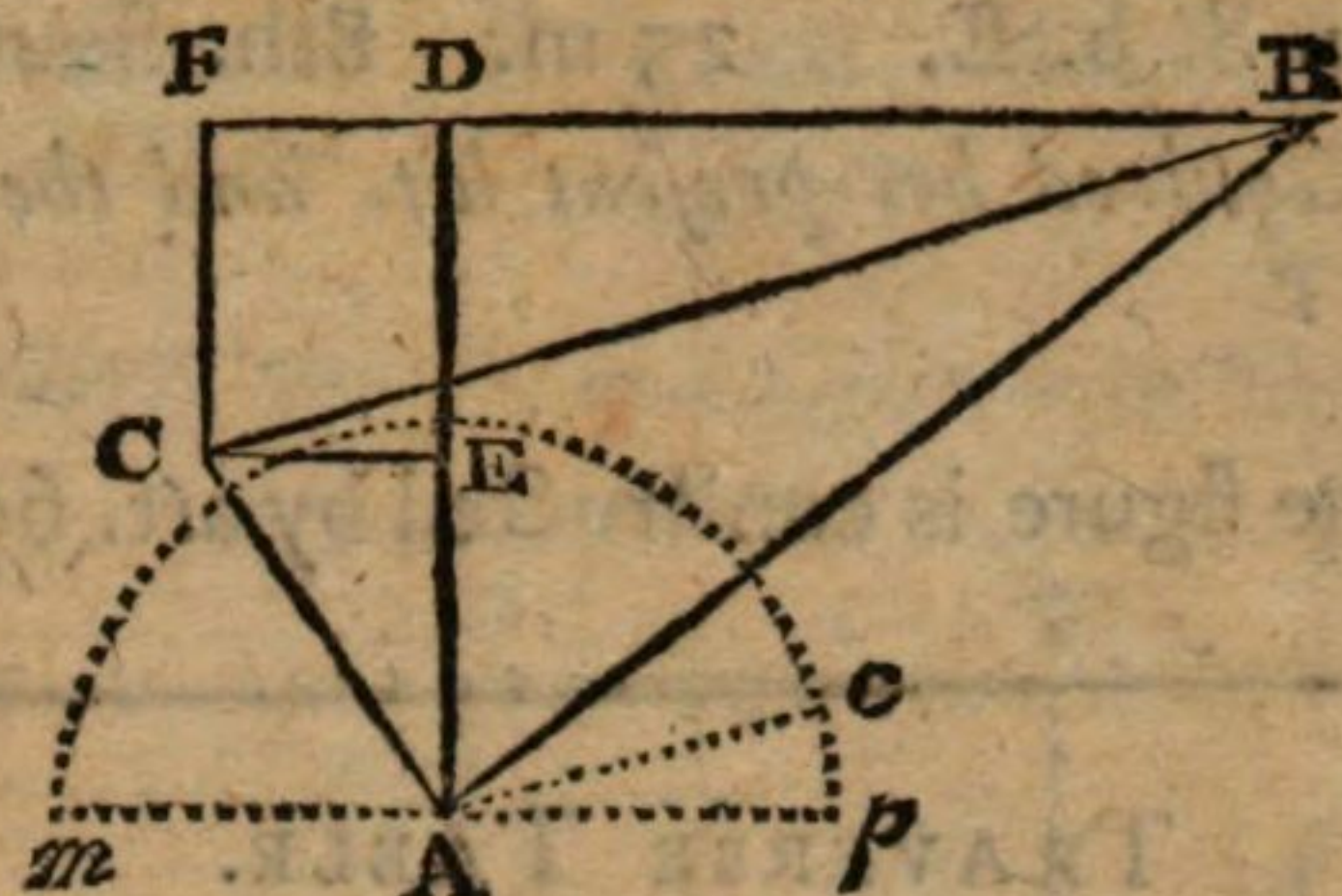
Lat. from $4^{\circ} 39'$ S.
Lat. in $0 \ 35$ N.

Diff. lat. $5 \ 14 = 314$ m.

AD = 594

AE = 314

ED = 280 = CF.



Long. from $83^{\circ} 16'$ E.

Long. to $95 \ 55$ E.

Diff. long. $12 \ 39 = 759$ miles.

DB = 759

FD = 200 = CE

FB = 959.

In the triangle CFB, to find the course and distance.

As CF : FB :: Rad : t. $\angle$ FCB. Or $280 : 959 :: t. 45^{\circ} 00' : t. 73^{\circ} 43'$.

As f. $\angle$ FCB : FB :: Rad : CB. Or f. $73^{\circ} 43' : 959 :: f. 90^{\circ} 00' : 999$.

Answer { The course is N. $73^{\circ} 43'$ E. or ENE. $\frac{1}{2}$ E.
The distance is 999 miles.

QUEST. XI. *A ship from the lat. $10^{\circ} 38'$ N. and bound to a port lying 282 miles to SW. b. S. after three successive days of bad weather, finds herself in lat. $3^{\circ} 58'$ N. and 120 miles to the eastward: Required her present course and distance to her intended port?*

The figure is constructed by art. 698.

In the triangle ABD, find AD and BD.

As Rad : AB :: f. $\angle$ B : AD.

Or Rad : 282 :: f. $56^{\circ} 15'$: 234,5.

And Rad : AB :: f. $\angle$ BAD : BD.

Or Rad : 282 :: f. $33^{\circ} 45'$: 156,6.

Lat. from $10^{\circ} 38'$ N.

Lat. in $3 \ 58$ N.

Diff. lat. $6 \ 40 = 400$ m.

AE = 400

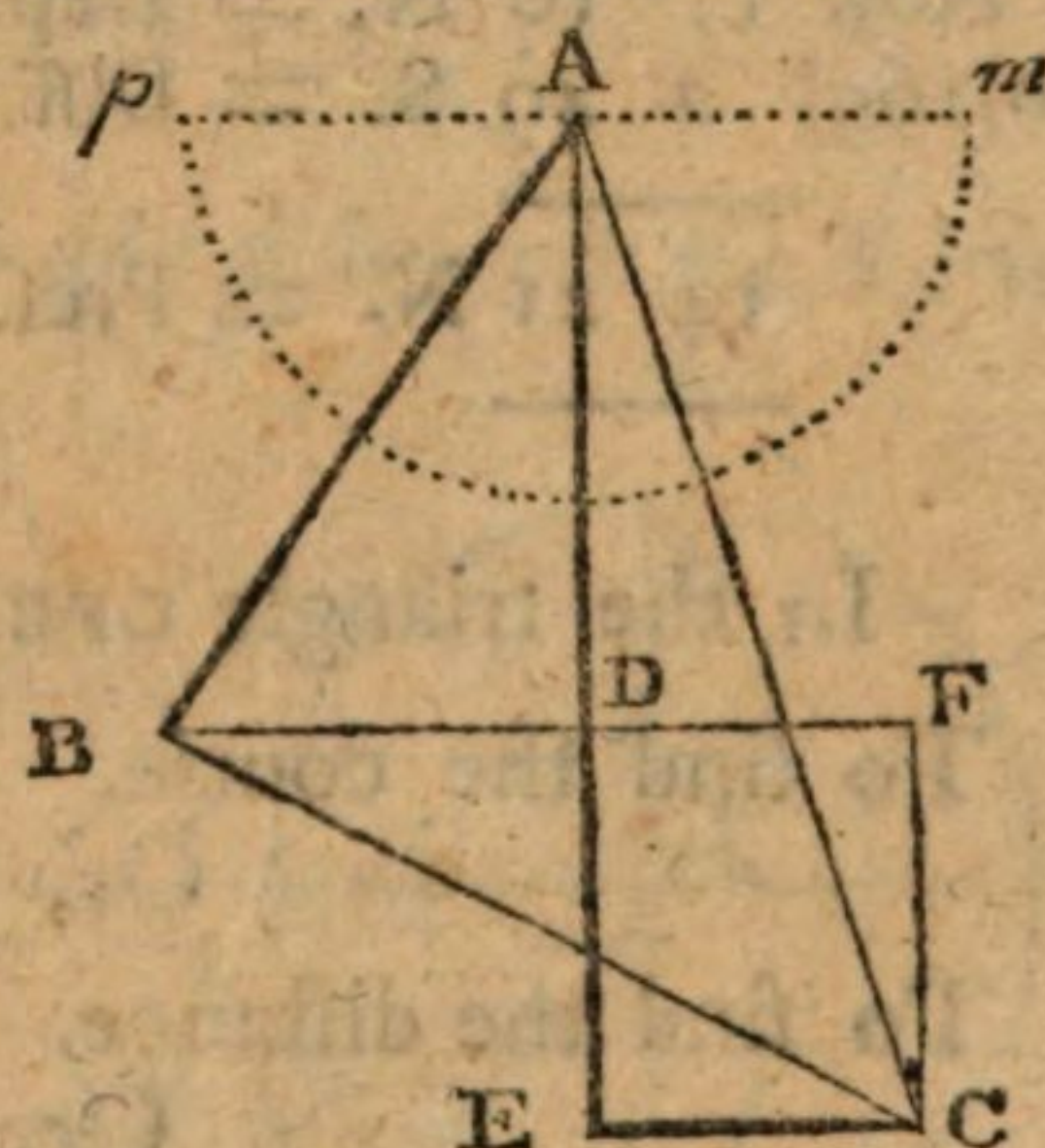
AD = 234,5

DE = GF = 165,5

BD = 156,6

EC = DF = 120

BF = 276,6



In the triangle CFB find the course and distance.

As CF : FB :: R : t. $\angle$ FCB. Or $165,5 : 276,6 :: \text{Rad} : t. 59^{\circ} 06'$.

As f. $\angle$ FCB : FB :: R : CB. Or f. $59^{\circ} 06' : 276,6 :: \text{Rad} : 322,4$.

Answer { Course is N. $59^{\circ} 06'$ W. Or NW. b. W. $\frac{1}{4}$ W.
Distance is 322,4 miles.

QUEST.

QUEST. XIII. Yesterday noon we were in latitude $0^{\circ} 15' S.$ and bound to a port bearing NE. b. N. $\frac{1}{2} E.$ in latitude $2^{\circ} 15' N.$; by the log we have run the following courses, viz.

NW. 25 m. NE. b. E. 28 m. E. b. S. $\frac{1}{4} E.$ 32 m. NNE. 41 m.
ESE. $\frac{1}{2} E.$ 24 m. NE. b. N. 39 m. WSW. 24 m.

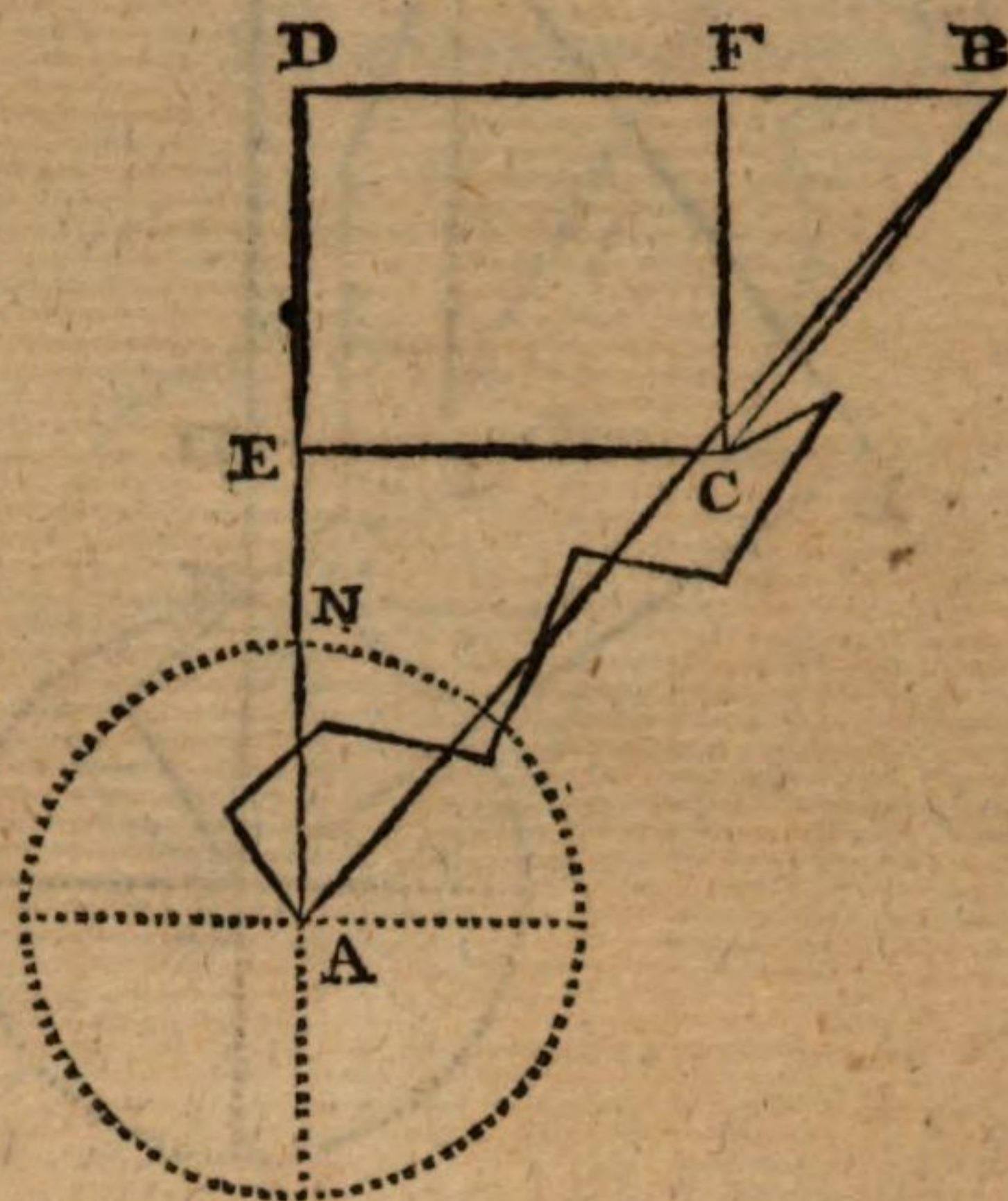
Required the ship's place, with the direct course and distance to the intended port?

The diff. lat. $AD = 150$ m.

In the triangle ADB , the departure DB will be found to be 123 m.

In the traverse, the diff. lat. $AE = 82,6$; and the departure $EC = 75,4$ miles.

In the triangle CFB , where $CF = 67,4$; $FB = 47,5$; the course is $N. 35^{\circ} 14' E.$ or NE. b. N. $\frac{1}{4} E.$; and the distance is 82,51 miles.



QUEST. XIV. A ship from the latitude of $18^{\circ} 14' N.$ is bound to a port bearing SW. b. S. $\frac{1}{2} W.$ and 138 miles to the westward; having sailed the following courses, viz.

SSW. 22 m. S. b. E. $\frac{1}{2} E.$ 38 m. NNE. 30 m. WSW. 57 m.
NNW 45 m. S. b. W. $\frac{1}{2} W.$ 50 m.

Required the ship's place, with the direct course and distance to the desired port?

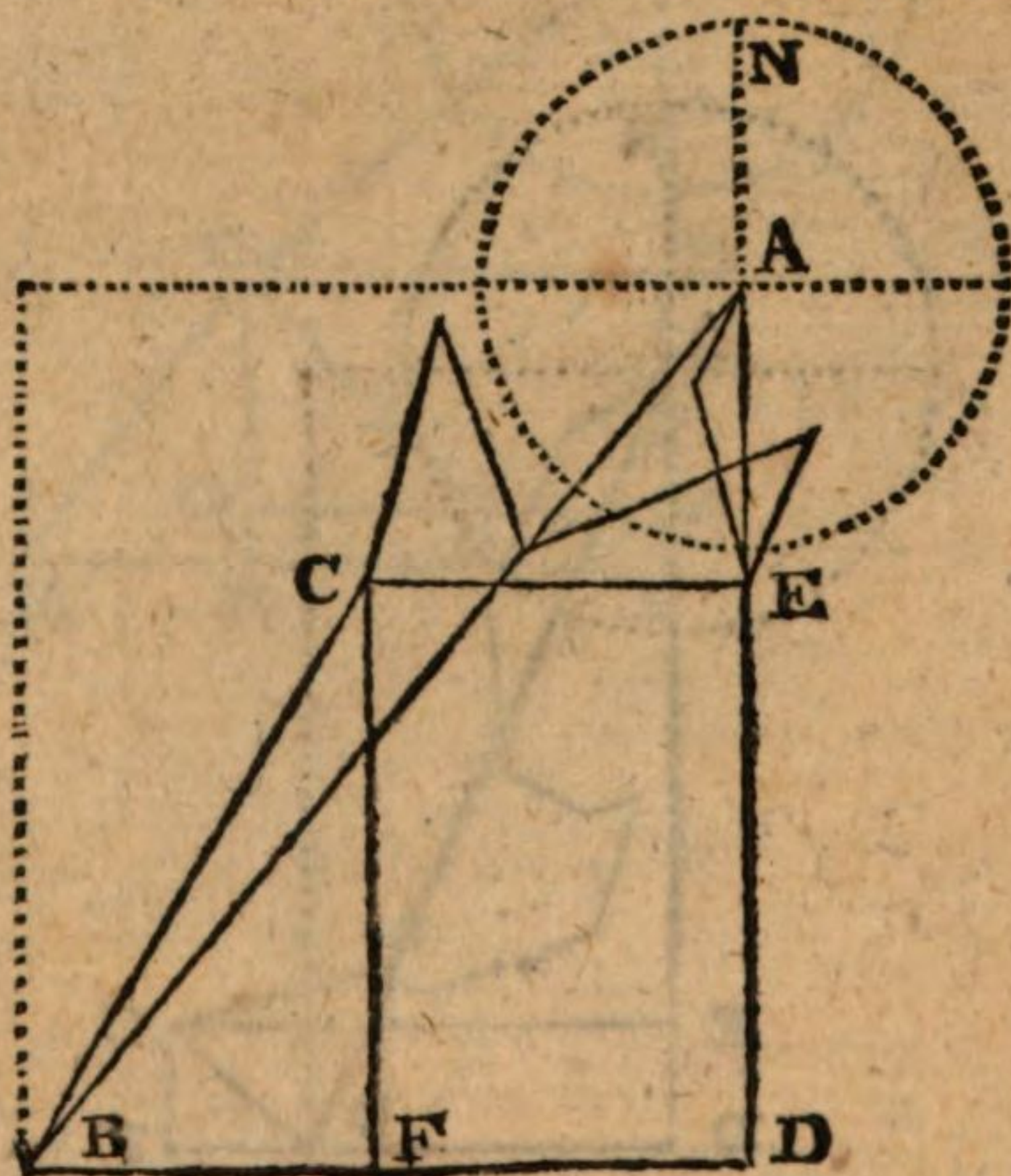
In the triangle ADB , the diff. lat. AD , will be found to be 168,2 miles.

In the traverse, the diff. lat. $AE = 57$ m. and the departure $CE = 70,3$ m.

In the triangle CFB , where $CF = 111,2$; $FB = 67,7$;

The course is $S. 31^{\circ} 20' W.$ or SSW. $\frac{3}{4} W.$

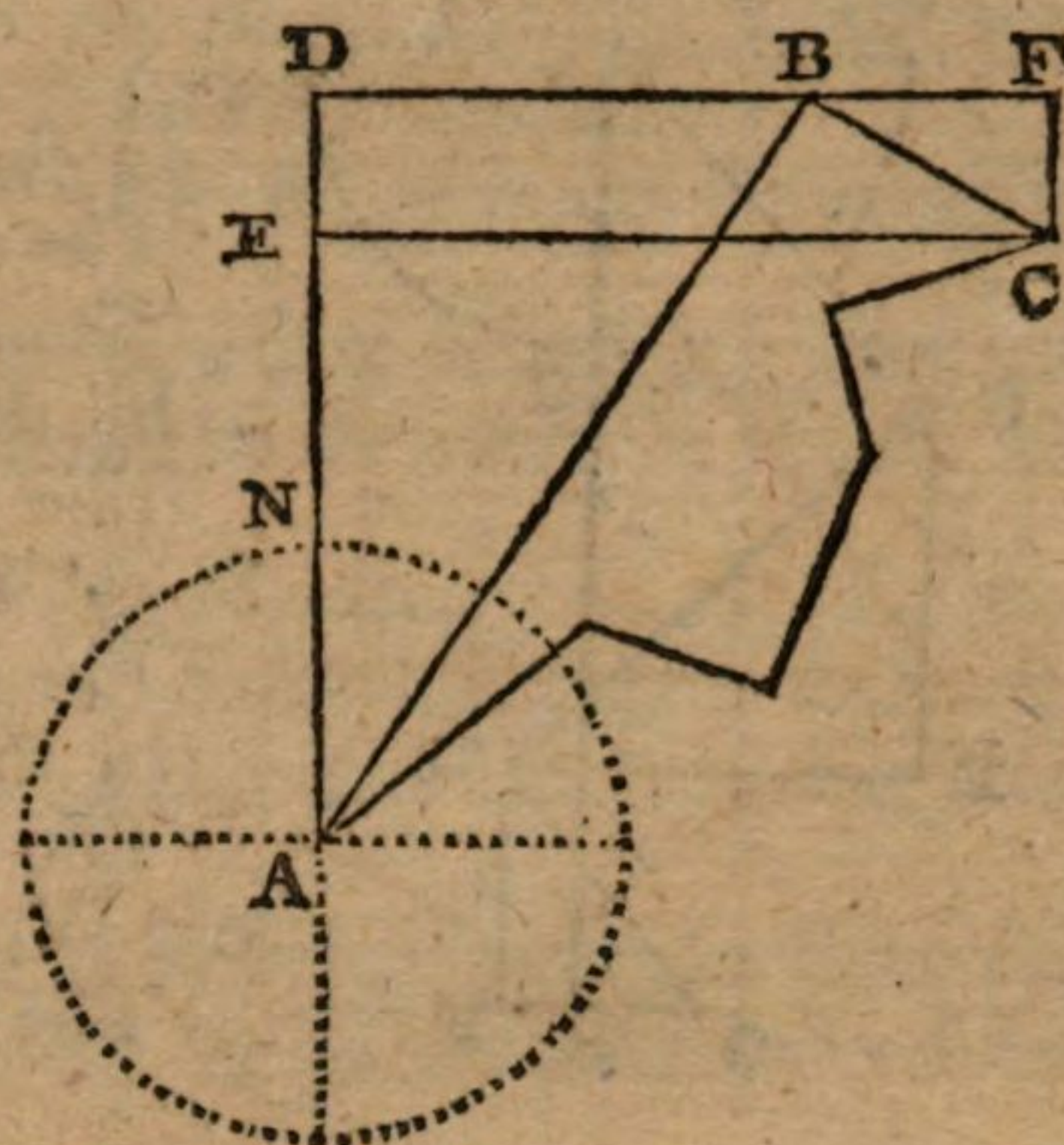
The distance is 130,2 miles.



QUEST.

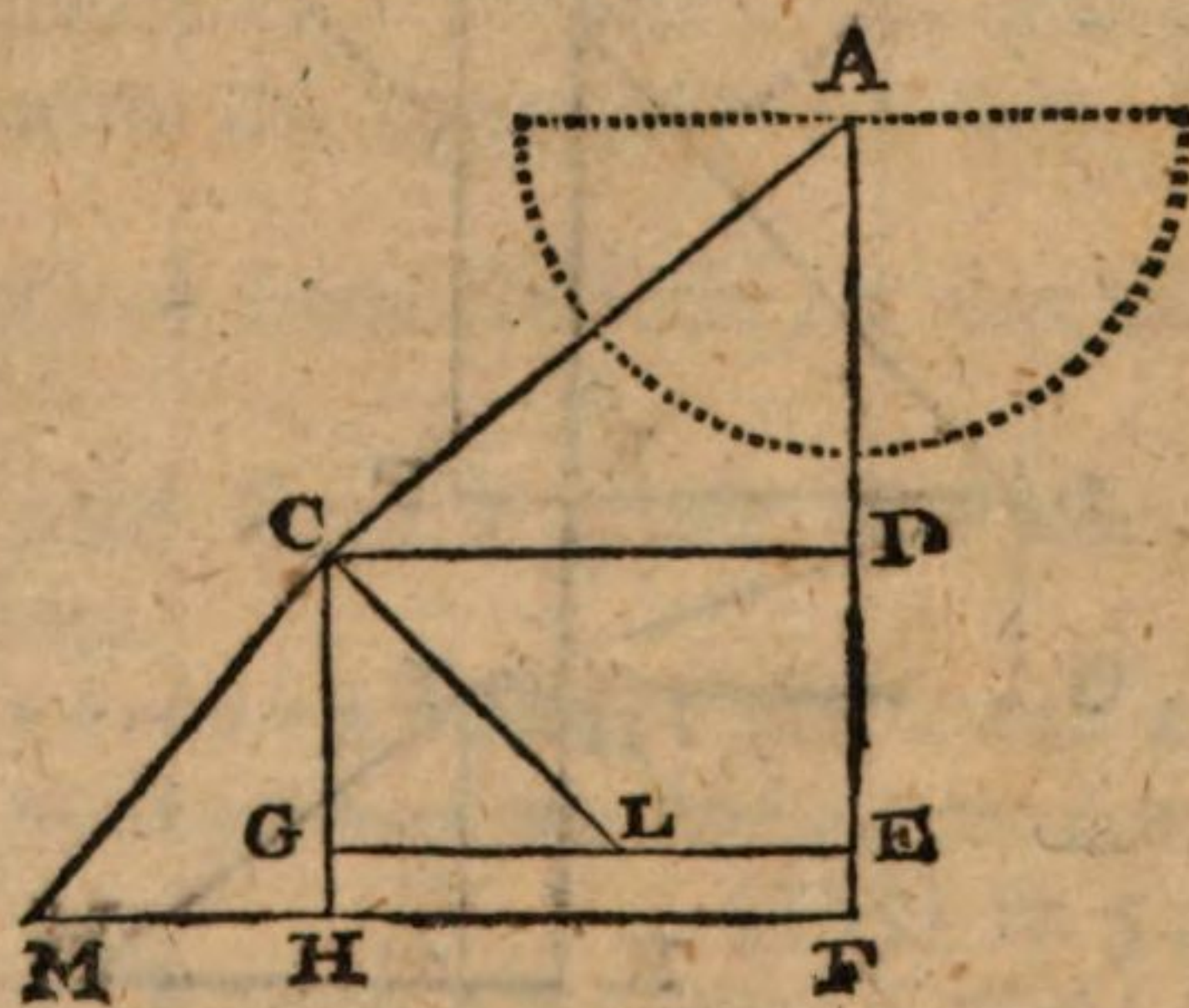
QUEST. XVII. *A ship from the latitude of $4^{\circ} 10' N$. being to make an Island that bears NE. b. N. distant 196 miles; having run these courses, viz. NE. $\frac{1}{2}$ E. 75 m. ESE. $\frac{1}{4}$ E. 42 m. NNE. $\frac{1}{4}$ E. 52 m. N. b. W. 34 m. ENE. $\frac{1}{2}$ E. 49 m. Desires to know her present latitude, with her direct course and distance to the Island?*

In the triangle ADE.
 The diff. lat. AD = 163.
 The depart. DB = 108,9.
 In the traverse AEC.
 The diff. lat. AE = 128.
 The depart. EC = 160.
 And the present lat. is $6^{\circ} 18' N$.
 In the triangle CFB.
 The diff. lat. CF = 35.
 The depart. FB = 51,1.
 The course is N. $55^{\circ} 36' W$.
 Or NW. b. W. nearly.
 The distance CB = 61,93 miles.



QUEST. XVIII. *Two ships take their departure from the Lizard in lat. $49^{\circ} 57' N$.; one bound to St. Michael's, which lies 715 m. to the S. and 745 m. to the west; the other bound to Lisbon, lying 661 m. to the S. and 215 m. west, reckoning from the Lizard: They sail in company SW. $\frac{1}{2}$ W. 610 miles, and then part: What is the direct course and distance of each ship to her port?*

In the triangle ADC.
 The diff. lat. AD = 387 m.
 The depart. DC = 471,5 m.
 In the triangle CGL.
 The course is S. $43^{\circ} 07' E$.
 Or SE. b. S. $\frac{3}{4}$ E. nearly.
 The distance CL = 375,3 m.
 In the triangle CHM.
 The course is S. $39^{\circ} 49' W$.
 Or SW. b. S. $\frac{1}{2}$ W. nearly.
 The distance CM = 427,1 m.



SECTION VI.

700.

Of oblique sailing.

In the preceding sections, the bearing and distances of places were determined by the solution of right angled triangles: But at sea there being many cases wherein only oblique positions can be observed, therefore 'tis necessary to shew how such cases are to be solved; which will be amply illustrated in this, and some of the following sections.

To set an object, is to observe what rhumb or point of the nautical compass is directed to it.

The bearing of an object, is the rhumb on which it is seen: And the bearing of one place from another is reckoned by the name of the rhumb passing thro' those two places.

In every figure relating to any case of plane sailing; the bearing of a line, not running from the centre of the circle or horizon, is found by drawing a line parallel thereto, from the centre, and towards the same quarter.

The figures belonging to the questions in this section are in Plate III. at the end, wherein the figures are referred to by the number of the question.

QUESTION I. *Two ships, A and B, sail from two Islands bearing the one from the other NE. and SW. their distance being 76 miles; A sails S. b. E. and B runs E. b. S. at last they meet: How far has each sailed?*

CONSTRUCTION. With the chord of 60° describe a circle representing the horizon of one of the places sailed from, suppose of A, the northern; draw the meridian NS , and at right angles to it draw the parallel EW .

In this circle lay off the SW . rhumb so , the $S. b. E.$ rhumb sp , and the $E. b. S.$ rhumb sm : Thro' o draw AB equal to 76 miles.

Thro' B draw BC parallel to Am , meeting AC drawn thro' p .

Then A and B represent the places sailed from; AC and BC the distances and courses (when properly compared with the meridian) the ships had sailed when they met at C .

The distances AC , BC , may be measured from the scale AB was taken from.

COMPUTATION. In the triangle ABC there is given one side AB , and all the angles, to find the other sides.

Thus, $\angle A = 5 \text{ pts.} = 56^\circ 15'$. For so and sp make 5 pts. meas. $\angle A$.

$\angle B = 5 \text{ pts.} = 56^\circ 15'$. For BC is paral. Am ; and $\angle B = \angle BAN$
(185) = 5 pts.

$\angle C = 6 \text{ pts.} = 67^\circ 30'$. For BC is paral. Am ; and $\angle C = \angle CAM$
(185) = 6 pts.

Therefore the solution belongs to Prob. I. (340).

And $f. \angle C : AB :: f. \angle A : BC$. Or, As $f. 67^\circ 30' : 76 \text{ m.} :: f. 56^\circ 15' : 68,4 \text{ m.}$

Now as $\angle B = \angle A$: Therefore AC is equal to BC . (194)

Answer { A sails $S. b. E.$ 68,4 miles.
 { B sails $E. b. S.$ 68,4 miles.

M m 2

QUESTION

QUESTION II. *Coasting along shore, a headland bore NE. b. N.; then having run E. b. N. 15 miles, the headland bore WNW.: Required the distance from the headland at each time of setting?*

The construction and computation of this question is made as in quest. I.; c being the headland, and AB the ship's run.

Answer, the distance is $\begin{cases} 8,496 \text{ m. at first setting.} \\ 10,81 \text{ m. at second setting.} \end{cases}$

QUESTION III. *In doubling a cape, I observed a castle up a river bore due N.; then running NW. 6 miles, the castle bore NNE.: Required my distance from the castle at each time of setting it?*

Here c is the castle, and AB the ship's run.

Answer, the castle's distance at $\begin{cases} \text{first is } AC = 14,48 \text{ m.} \\ \text{last is } BC = 11,08 \text{ m.} \end{cases}$

QUESTION IV. *At noon a headland bore NW. b. W.; then sailing NNE. 5 miles an hour, we anchored at 9 in the evening in a creek 18 leagues distant from the headland: Required its distance at noon, and bearing from the creek?*

CONSTRUCTION. Having described the horizon and drawn the meridian and parallel, in the meridian take any point A for the ship's place at first: Draw the NW. b. W. and NNE. rhumbs, and parallel to them draw AB, AC.

Make $AC = 45 \text{ m. } (= 9 \text{ h.} \times 5 \text{ m.})$: And from c with $54 \text{ m. } (= 18 \text{ l.} \times 3)$ cut AB in B. Then B is the headland, and c the creek.

COMPUTATION. Here is given the side $AC = 45 \text{ m.}$; the side $CB = 54 \text{ m.}$ and the $\angle A = 78^\circ 45' = 5 \text{ pts for NW. b. W, } + 2 \text{ pts. for NNE.}$

Therefore the solution falls under Prob. I. (340)

And $\angle B = 54^\circ 49'$; therefore $\angle C = 46^\circ 26'$; and $AB = 39,9 \text{ miles.}$ Draw ao parallel to CB; then $\angle CBA = \angle oan = 54^\circ 49'$.

Therefore $\angle oan - \angle naw = \angle oaw = 21^\circ 04'$; which taken from $90^\circ 00'$ leaves $68^\circ 56'$

Answer, the headland's $\begin{cases} \text{distance at noon is } 39,9 \text{ miles.} \\ \text{bearing from the creek is S. } 68^\circ 56' \text{ W. or} \\ \text{WSW. } \frac{1}{4} \text{ W. nearly.} \end{cases}$

QUESTION V. *A ship after sailing SE. b. S. 62 leagues from her port in lat. $29^\circ 16'$ N. meets a sloop that had run 124 leagues from a place bearing W. b. N. of the port the ship departed from: What was the sloop's course, and the distance of the two ports?*

The construction and computation being made as in the last, A and B represent the ports sailed from; and c the place where the vessels met.

Answer $\begin{cases} \text{The distance of the ports is } 72,18 \text{ miles.} \\ \text{The sloop's course along cb is S. } 58^\circ 03' \text{ E. or SE. b. E. nearly.} \end{cases}$

QUESTION

QUESTION VI. *A merchant ship meeting with a ship of war, who had sailed SE. b. E. 39 leagues from the latitude of $45^{\circ} 30' N.$ informed them that he had been plundered the day before in the same latitude; and had since run 67 leagues on a direct course between the south and west; and that the pyrates were cruising about the place where they robbed him: What course must the man of war steer to come up with them?*

Suppose A the place the man of war sailed from, B the place where the merchant man was robbed, C the place where they met; then the man of war must sail along CB to meet the pyrates; which course will be shewn by cn drawn parallel to CB.

Here the given distance AC is not drawn from the centre of the circle representing the horizon, but parallel to co the given course; this was done, in order to prevent the figure from being so small as it must otherwise have been.

Here are given two sides and an angle opposite to one of them, to find the angle B opposite to the other side AC.

Then $CB : \sin \angle A :: AC : \sin \angle B$. That is, As 67 l. : $33^{\circ} 45'$:: 39 l. : $18^{\circ} 52'$.

ANSWER. The course the man of war must steer is N. $71^{\circ} 08'$ E.

For $\angle nCB = \angle CBc$ (185); and $90^{\circ} - \angle nCB = \angle Ncn$.

QUESTION VII. *Two ships sail at the same time from one port; one sails ESE. and the other SSE. : Required their bearing and distance when each has run $37\frac{1}{2}$ miles?*

Here, $AB = AC$; therefore $\angle B = \angle C$. Now $\angle A = 4$ pts.; then $\angle C = \angle B = 6$ pts.

ANSWER. B bears from C N. 45° E. distant 67,12 miles.

QUESTION VIII. *Sailing on a SW. course at the rate of $4\frac{1}{2}$ miles an hour, at 9 o'clock in the forenoon a cape bore SE. b. E. distant 15 miles: Required its bearing and distance at 4 o'clock in the afternoon?*

ANSWER. The cape B bears N. $68,08$ E. distant 37,44 miles.

Here the ship is at A at 9 o'clock, and at C at 4 o'clock: The two sides AC, AB, and the contained angle A = 9 pts. are given, to find the rest.

QUESTION IX. *Wanting to know the breadth of a river in whose mouth are several islands; from a cliff on the eastern side, I sailed NNW. 50 miles; and then running SSW. 35 miles, I reached the western shore: Required the breadth between those places?*

Here, $AB = 50$ m. $BC = 35$ m. and $\angle B = 4$ pts. Required AC.

ANSWER. The breadth between A and C is 35,35 miles.

QUESTION

QUESTION X. *From two ports lying under the same meridian and distant 236 miles, two ships sail towards the east, and meet when each has run 372 miles: Required the course of each?*

In Fig. X. A and B are the ports sailed from, and c the place where the ships met. Here are given the three sides; but two of them being equal, the solution is easily found by drawing the perpendicular CD. (344)

ANSWER. A's course is S. $71^{\circ} 30'$ E. and B's course N. $71^{\circ} 30'$ E.

QUESTION XI. *Two ships meeting at sea, find they had sailed from two ports in the same latitude, and distant 576 miles: The ship from the western port had run between the N. and E. 328 miles, and the other had sailed 416 miles: Required the course steered by each ship?*

A and B are the ports sailed from, and c the place where the ships met. From the three given sides, the angles may be found by art. 344 or 345.

ANSWER. The course from A is N. $44^{\circ} 49'$ E. and from B is N. $55^{\circ} 59'$ W.

QUESTION XII. *A sloop in three days coasted round a triangular shaped island; the first day she ranged along one side, and her courses reduced to one was SW. distance 64 miles; the second day's distance was 106 miles between the S. and E.; and that of the third day was 83 miles: Required the direct courses of the second and third days?*

In Fig. XII. the first day's distance is AB, the second BC, the third AC. And the figure is thus constructed.

Having described the horizon, and drawn the meridian and parallel (681), their intersection A is taken for the place the ship sailed from; draw the SW. rhumb $AB = 64$ miles; from A and B describe arcs with the radii 106 and 83; to their intersection c, draw the lines BC, AC.

Draw the line Ar parallel to BC, and continue CA to o.

Then the arc sr measures or gives the second day's course.

And the arc No the course of the third day.

Now the angles being found by either method, as in art. 357; the courses will be thus obtained.

From $\angle BAC$ take 4 pts. $= \angle SAB$, leaves $\angle SAC$.

Then arc sr, or $\angle SAR = \angle SAC + \angle C (= \angle CAR$ by 185) for the second course.

And arc No, or $\angle NAo = \angle SAC$ (183) is the 3d day's course.

ANSWER. The second day's course is S. $83^{\circ} 29'$ E. and the third day's N. $46^{\circ} 21'$ W.

The directions given for this 12th question may be applied to the two preceding ones.

QUESTION

QUESTION XIII. *Sailing into a harbour I observed two landmarks, the one bore E. the other W.; and after running S. 3,3 miles, the eastern one bore N. $58^{\circ} 30'$ E. and the western one N. $47^{\circ} 20'$ W.: Required my distance from those landmarks at each time of setting them?*

The ship is supposed first at A, and sees the landmarks c and d in the lines AC, AD; then sailing to B, she sees the same marks in the lines BC, BD, drawn parallel to the given rhumbs A n, A o.

Here are two right angled triangles BAC, BAD, to work in; there being known in each, the side AB, and all the angles; whence the solution will be as in art. 347.

ANSWER. $AD = 3,58$ m. $AC = 5,385$ m. $BD = 4,87$ m. $BC = 6,316$ m.

QUESTION XIV. *Coasting along shore I observed two islands, the one bore E. and the other W.; then sailing SSE. $\frac{1}{2}$ E. $16\frac{1}{2}$ miles, the western island bore NW. b. W. $\frac{1}{2}$ W. and the eastern bore NE. $\frac{1}{4}$ E.: Required their distance at each time of setting them?*

Here are two oblique angled triangles to work in; and the solution will be as in art. 349; there being one side AB and all the angles known.

ANSWER. $AC = 22,99$ m. $AD = 23,85$ m. $BC = 34,03$ m. $BD = 21,67$ m.

QUESTION XV. *Three ships, B, C, D, sail from the same road A, and bound to different ports lying in the same parallel of latitude; B's course is NW. b. N. distance 12 miles; C's course is NE. b. E.; and D's course is ENE. $\frac{1}{2}$ E.: Required the distance of C and D from their ports, and also the distance of those ports from one another?*

Having described the horizon, and drawn the meridian and parallel, let their intersection c represent c's port; draw the given rhumbs c o, c n, c r; make c o = 12 miles, produce n c towards A, and parallel to n A draw o B, meeting the west line in B; draw BA parallel to o c, and draw AD parallel to c r, meeting the east line in D: Then A is the port sailed from, and B, C, D are the ports bound to.

The solution of these triangles falls under art. 347 and 349; there being given one side and all the angles.

Thus $\angle BAC = 8$ points, $\angle B = 5$ points, $\angle BCA = 3$ points.

The $\angle BAD = 9\frac{1}{2}$ points, $\angle D = 1\frac{1}{2}$ points.

ANSWER. $AC = 17,96$ m. $AD = 34,36$ m. $BC = 21,6$ m. $BD = 39,56$ m.

QUESTION

QUESTION XVI. *Two ships, A and B, sail from the port C; A sails SSE. 50 miles, and B SW. b. S. 40 miles: Required their bearing and distance; and how far A is to the southward and eastward of B?*

Describe the horizon, draw the meridian and parallel, and their intersection c represents the port sailed from.

Draw the given rhumbs, in which take $CA = 50$, $CB = 40$; then A and B represent the places the ships are come to.

Draw AB; thro' B draw the meridian BD, meeting the parallel AD drawn thro' AD: Then BD is the difference of latitude, DA the departure, and BA shews the bearing and distance sought.

In the triangle CBA, find the unknown angles, and side BA by art. 355.

Draw $c n$ parallel to BA; then $\angle sca + \angle cas (= \angle ac n (185))$ gives $\angle sc n$ the bearing from B to C: And $\angle sc n$ taken from 90° leaves $\angle BAD$: Hence BD, DA, are found by art. 347.

ANSWER. $BA = 43,33$ miles, $BD = 12,93$ miles, $DA = 41,36$ miles.
And the bearing from B to A is S. $72^\circ 38'$ E.

QUESTION XVII. *At sunrise, being four o'clock, a ship saw a sloop to the WNW. and a brig to the E. b. N.; they all came to anchor along side one another at nine o'clock, each having run since sunrise five knots an hour, and the ship's course was due north: Required the courses sailed by the sloop and brig, and their distance from the ship in the morning when she set them?*

Draw the WNW. and E. b. N. rhumbs ao , an ; assume any point D in the meridian line for their anchoring place, and in the same line take $DA = 25$ miles = the distance each sailed; thro' A draw AC, AB, parallel to ao , an , and on D with the radius DA describe a circle cutting AC, AB, in C, B: Then A is the ship's place, C the sloop's, and B the brig's, at four in the morning.

Now $\angle C = \angle DAC = \angle D a o = 6$ points; therefore $\angle ADC = 4$ points.

And $\angle B = \angle DAB = \angle D a n = 7$ points; therefore $\angle ADC = 2$ points.

The sides AC, AB, will be found by art. 351.

Answer $\left\{ \begin{array}{l} CA = 19,13 \text{ miles, and } c's \text{ course is NE.} \\ BA = 9,755 \text{ miles, and } B's \text{ course is NNW.} \end{array} \right.$

QUESTION XVIII. *Having dropt anchor in very deep water in a river with a buoy and rope of 50 fathoms fixed to it, I fell down the stream till I had veered out 140 fathoms of cable, and then the buoy was 120 fathoms a-head of me: Required the depth of water?*

Construct the triangle ABC with the three given sides, letting $CA = 120$ be horizontal to represent the surface of the water.

Draw

Draw BD perpendicular to CA continued; then B represents the anchor, A the buoy, C the ship, and BD the depth of water.

In the triangle ABC find by art. 345 the angle CAB ; then its supplement DAB will also be known; and in the right angled triangle ADB , the side AB and all the angles being known, the side BD may be found as in art. 347.

ANSWER. The depth of water DB is 48,71 fathoms.

QUESTION XIX. *Coming within sight of two headlands bearing N. and S. of each other, the southern one bore from the ship due E. and the other NE. b. E.; and after sailing due E. 5 miles, the northern headland bore NE. b. N. $\frac{1}{2}$ E.: Required the distance of those headlands from one another, and their distance from the ship at each time of setting them?*

In the east and west line take $BA = 5$ miles; draw the NE. b. E. and NE. b. N. $\frac{1}{2}$ E. rhumbs Bn , BD ; thro' A draw AD parallel to Bn , meeting BD in D ; draw DC perpendicular to AB continued.

Then D and C are the headlands; A , B , are the ship's places at the times of setting them, and AB the distance sailed.

Now $\angle A = (\angle CBn \text{ by } 185 =) 3 \text{ points}$; the $\angle DBC = 4\frac{1}{2} \text{ points}$.

Then $\angle ABD = 11\frac{1}{2} \text{ pts. (181)}$; $\angle ADB = 1\frac{1}{2} \text{ pts.}$ and $\angle BDC = 3\frac{1}{2} \text{ pts.}$

In the triangle ABD having the side AB , and all the angles given, find the sides AD , BD , by art. 349.

And in the right angled triangle BCD , knowing the side BD and all the angles, find the sides BC , CD , by art. 347.

ANSWER. $AD = 13,31 \text{ m.}$ $BD = 9,565 \text{ m.}$ $BC = 6,07 \text{ m.}$ $CD = 7,395 \text{ m.}$

QUESTION XX. *Having cast anchor I observed the bearings of a tower, a mill and a lighthouse, known to lie due east and west of one another; the tower bore WSW. the mill SW. b. S. $\frac{1}{2}$ W. and the lighthouse S. b. W. $\frac{1}{2}$ W.; the distance of the tower from the mill is $5\frac{1}{2}$ miles: How far are each of those objects distant from the place where I anchored?*

Draw the given rhumbs Br , Bo , Bn ; make $BA = 5\frac{1}{2}$ miles; continue oB till it meets AD , drawn parallel to Br , in D ; draw DC parallel to Bn : Then D represents the ship's place, A the tower, B the mill, and C the lighthouse.

The angles are made out, and the triangles are solved as in the last question.

ANSWER. $DA = 9,021 \text{ m.}$ $DB = 4,466 \text{ m.}$ $DC = 3,608 \text{ miles.}$

SECTION VII.

Of sailing to windward.

701. When the wind is directly, or partly, against a ship's direct course to the place she is bound to, she reaches her port by a kind of zigzag or z like course; which is made by sailing with the wind first on one side the ship, and then on the other side.

In a ship, and looking towards the *stem* or *head*.

STARBOARD signifies the right hand side.

LARBOARD the left hand side.

FORWARDS or AFORE, is towards the head or stem of the ship.

AFT or ABAFT, is towards the hinder part or *stern*.

The BEAM signifies *athwart* or across the middle of the ship.

702. When a ship sails the same way the wind blows, she is said to sail or run before the wind; and the wind is said to be *right aft*, or *right astern*; and her course is then 16 points from the wind.

When a ship sails with the wind blowing directly across her, she is said to have the *wind on the beam*; and her course is 8 points from the wind.

When the wind blows obliquely across the ship, the wind is said to be *abaft the beam*, or *afore the beam*, according as her course is more or less than 8 points from the wind.

When a ship endeavours to sail towards that point of the compass from whence the wind blows, she is said to *sail on a wind*, or to *ply to windward*.

A vessel sailing as near as she can to the point from whence the wind blows, is said to be close hauled: The generality of ships will lie within about six points of the wind; but sloops and some other vessels will lie much nearer.

703. The *windward*, or *weather, side*, is that side of the ship on which the wind blows; and the other side is called the *leeward*, or *lee side*.

Tacks and *sheets* are large ropes made fast to the lower corners of the fore and main sails, by which either of these corners are hauled fore or aft.

When a ship sails on a wind, the windward tacks are always hauled forwards, and the leeward sheets aft.

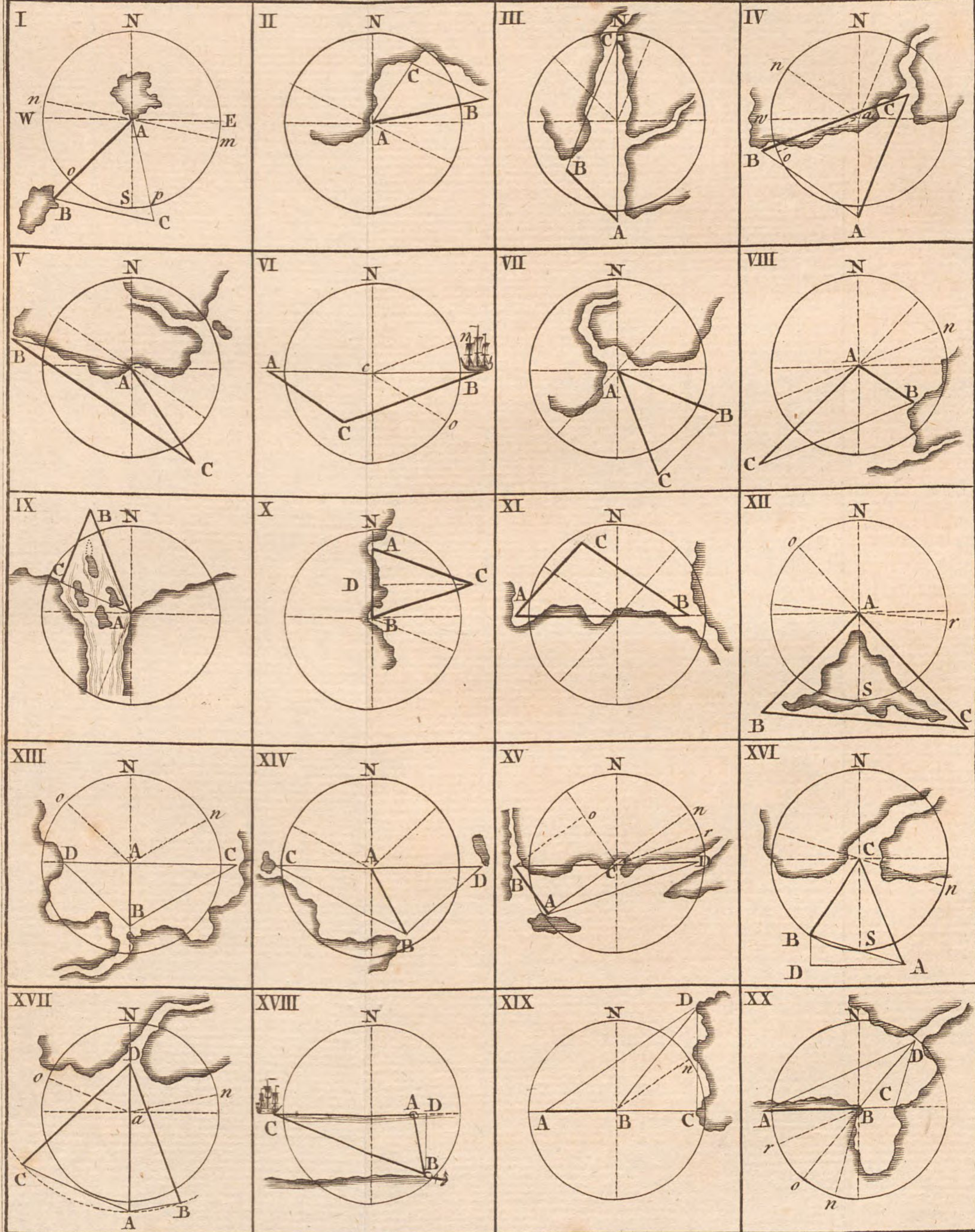
The *starboard tacks* are aboard when the starboard side is to windward, and the larboard to leeward.

And the *larboard tacks* are aboard when the larboard side is to windward, and the starboard to leeward.

704. To know how near the wind a ship will lie; observe the course she goes on each tack, when she is close hauled; then half the number
of

OBLIQUE SAILING

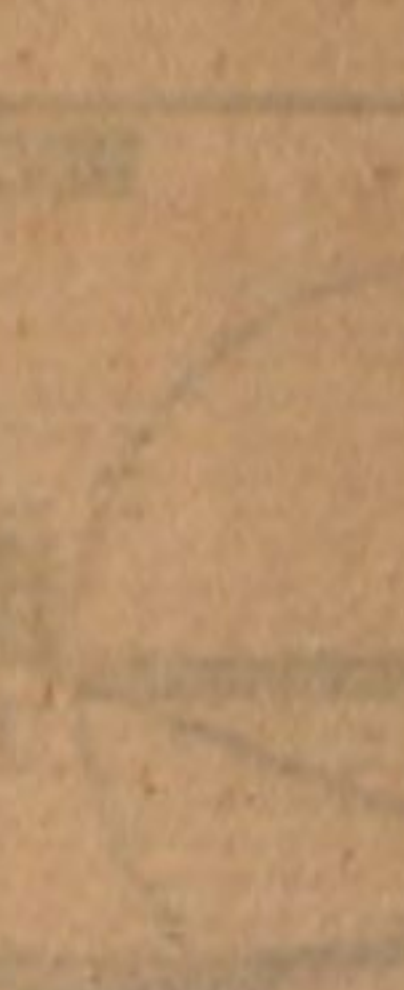
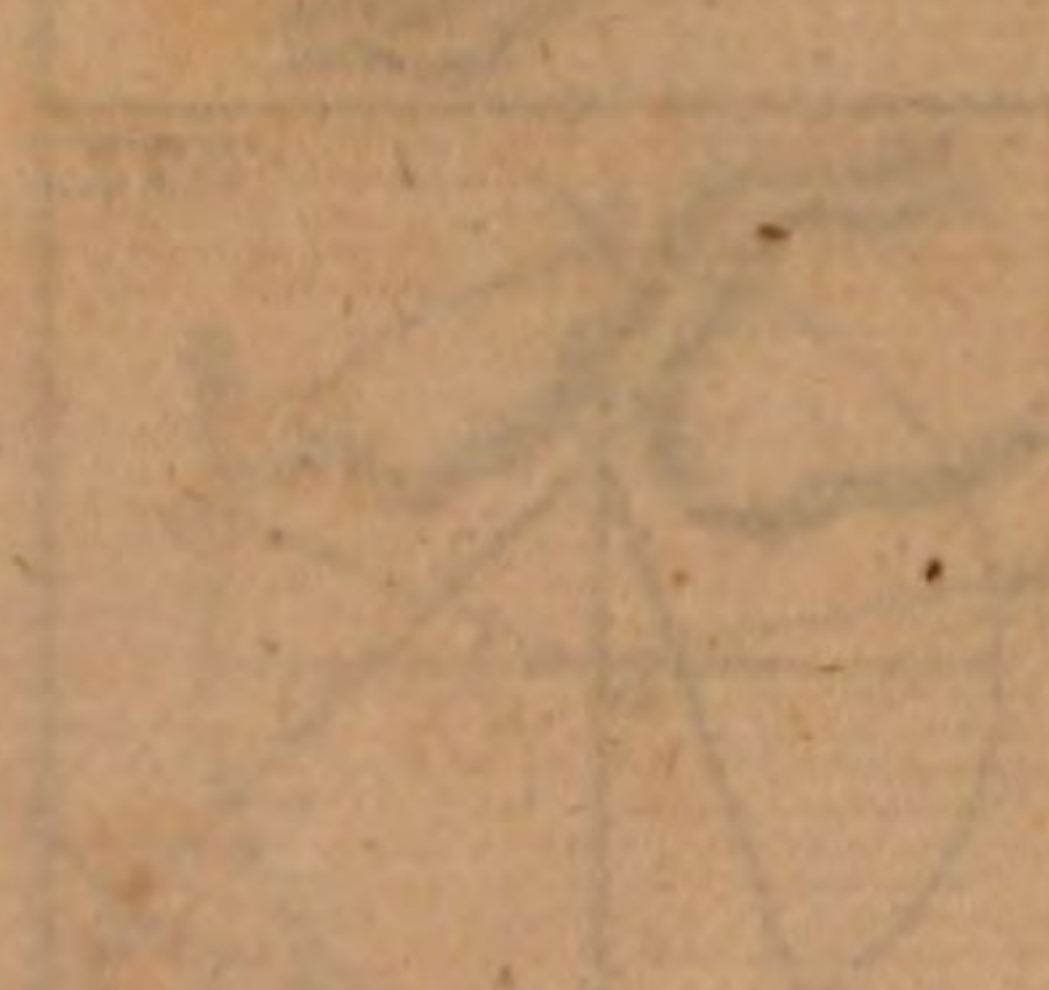
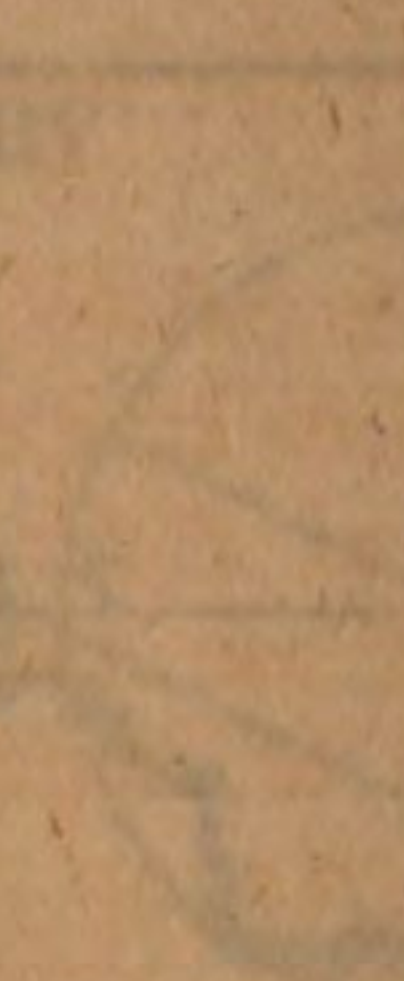
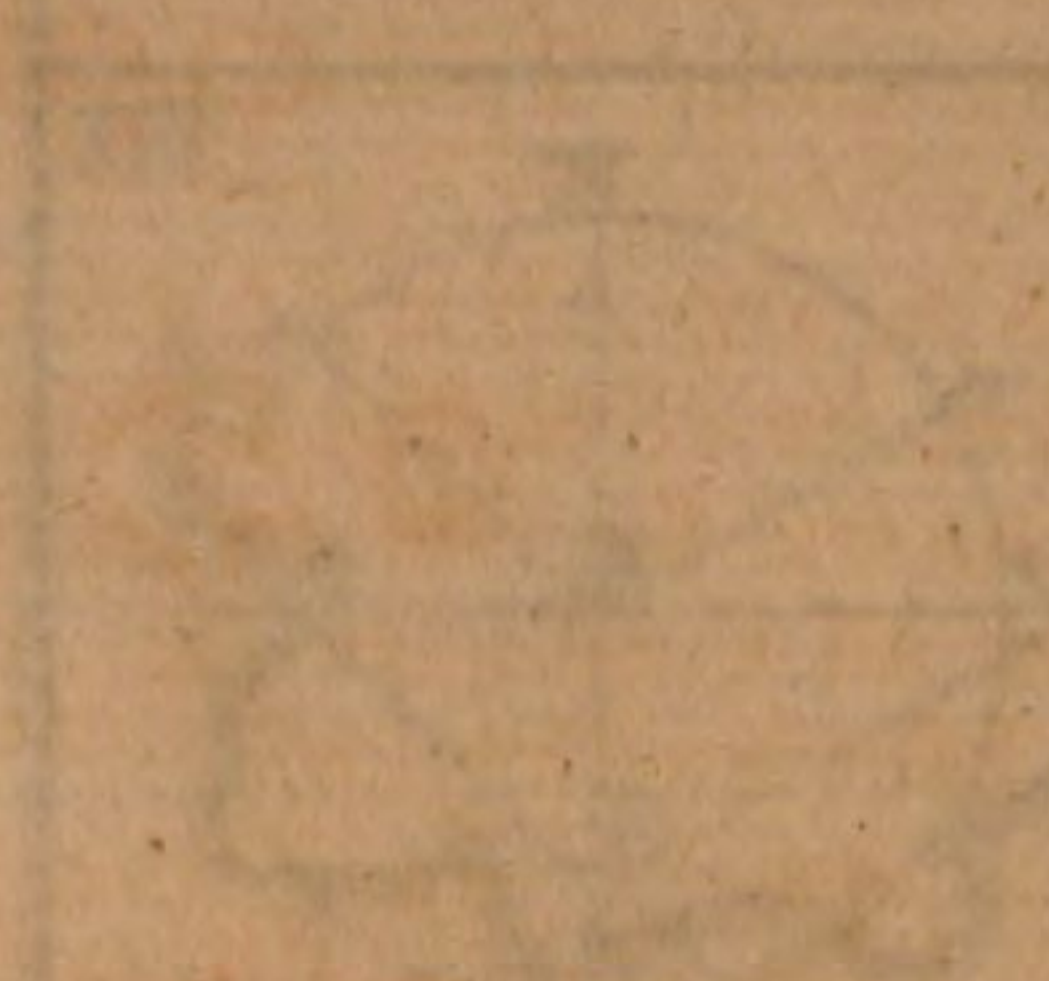
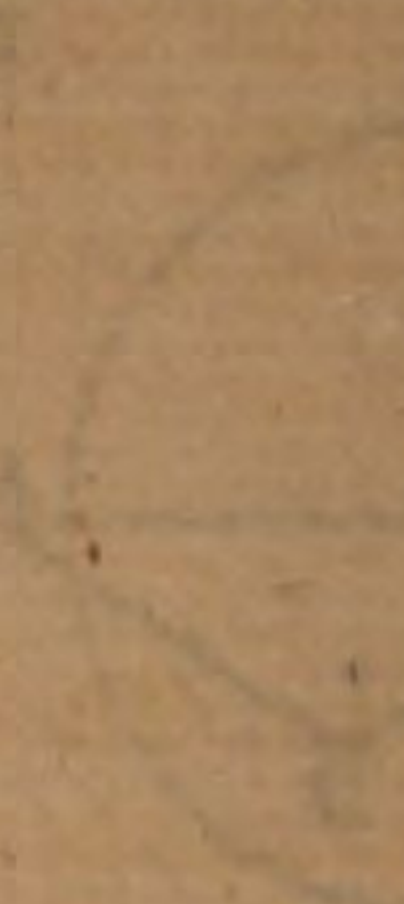
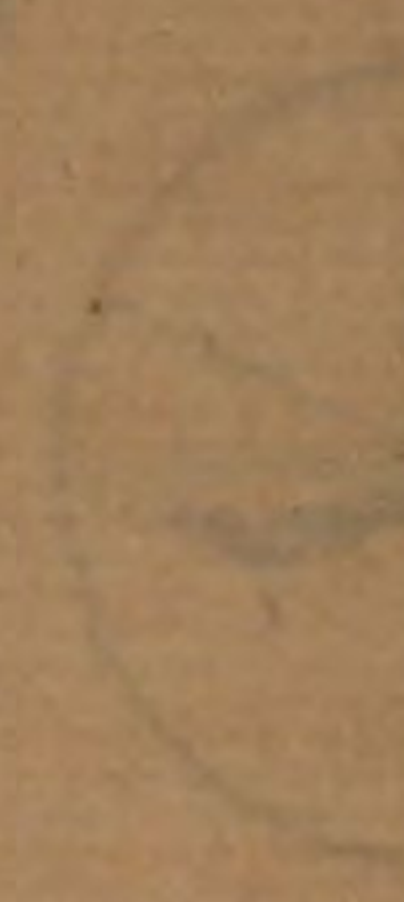
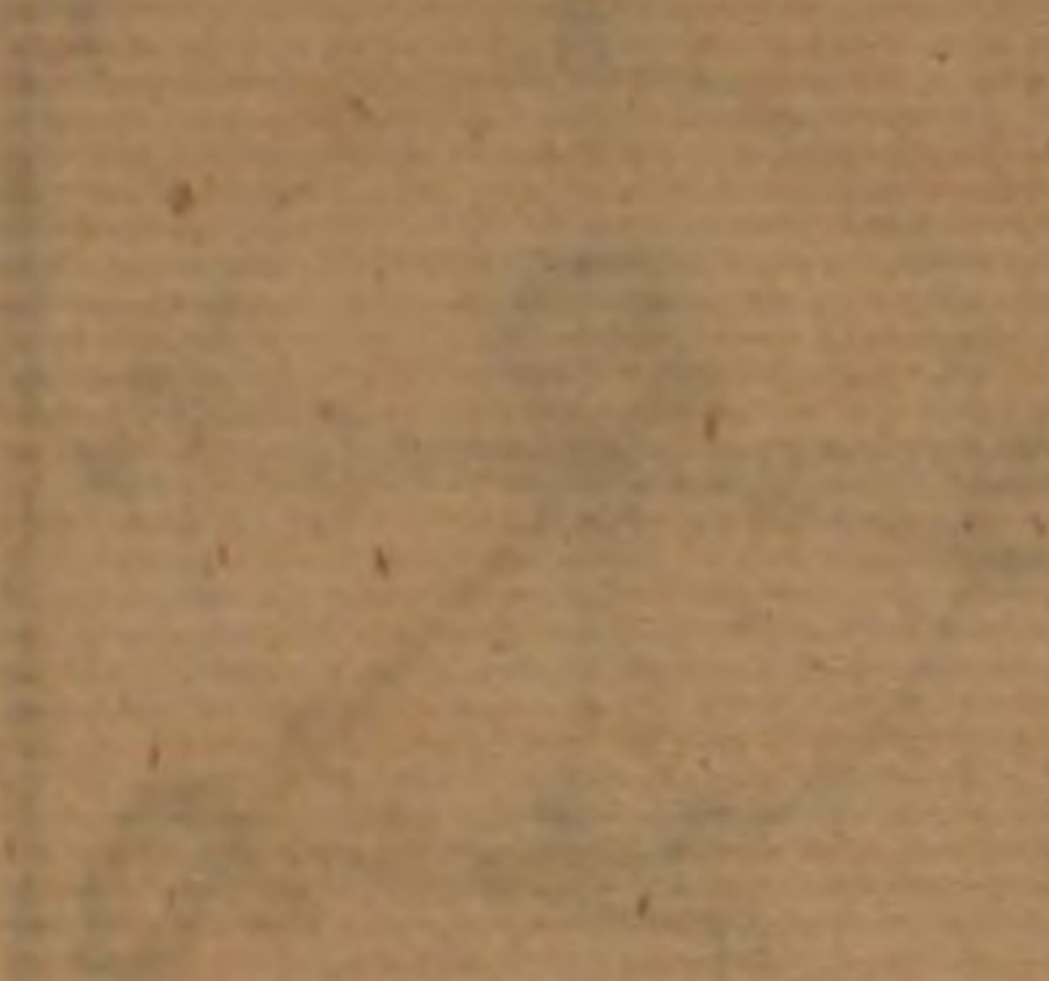
Pl. III.



III. PI



III. PI



of points between the two courses, will shew how near the wind that ship will lie.

705. The most common cases in turning to windward may be constructed by the following precepts.

Having drawn the meridian and parallel of latitude (or east and west line) in a circle representing the horizon of the place; mark in the circumference the place of the wind; draw the rhumb passing thro' the place bound to, and lay thereon the distance of that place from the centre.

On each side of the wind, lay off in the circumference, the points or degrees shewing how near the wind the ship can lie; and draw these rhumbs.

Now the first course will be on one of these rhumbs, according to the tack the ship leads with: Draw a line thro' the place bound to, parallel to the other rhumb and meeting the first, and this will shew the course and distance on the other tack.

The figures referred to in this section are in Plate IV. at the end; wherein they are marked by the number of the question.

QUESTION I. *The wind at north, and I am bound to a port 25 miles directly to windward; being on my starboard tacks, and can lie within 6 points of the wind: What must be my course and distance on each of two tacks to reach my port?*

The construction being done as above directed, N is the place of the wind, A the port bound to, and B the place where the ship is supposed to be, when the port is 25 miles to windward of her.

Now as the ship leads with her starboard tacks; that is, has the wind blowing on her starboard side, she must first sail along the line BC drawn parallel to the rhumb A n, which is 6 points from the wind; and where the other rhumb A o, also 6 points from the wind, being produced from A towards C, meets with BC in the point C, is the place where she must tack about to reach her port within 6 points of the wind on her larboard tacks.

Here BC being parallel to A n, the $\angle B = (\angle N A n, \text{ by } 183, =) 6 \text{ points.}$

And the $\angle BAC = (\angle N A o, \text{ by } 183, =) 6 \text{ points; hence } \angle C = 4 \text{ pts.}$

Therefore, as $\angle B = \angle BAC$; the side BC = side CA (194)

Now as one side AB, and all the angles are given, the solution falls under art. 340 of opposite sides and angles.

Therefore, As $\sin. \angle C : AB :: \sin. \angle BAC : BC.$

Or, As $\sin. 45^\circ 00' : 25 \text{ m.} :: \sin. 67^\circ 30' : 32,66.$

ANSWER, the ship sails { on her starb. tacks *WNW*. 32,66 miles.
on her larb. tacks *ENE*. 32,66 miles.

QUESTION II. *A ship that is bound to a port 80 miles directly to windward, then at NE. b. N. $\frac{1}{2}$ E. proposes to reach her port at two boards each within 6 points of the wind: Required her course and distance on each tack, so as to double a rocky shelf lying in the NW. quarter?*

As the wind is in the NE. quarter, and the ship is to double a shelf in the NW. quarter, therefore she must lead with her starboard tacks; and running from B, her present place, to C in a parallel to the rhumb A n, 6 points from w the place of the wind; she then tacks for her port A, in the direction of the rhumb A o, 6 points from w.

The manner of solution, is the same as in the last question.

ANSWER, she runs on her $\left\{ \begin{array}{l} \text{starb. tacks NNW. } \frac{1}{2} \text{ W. } 104,5 \text{ miles.} \\ \text{larb. tacks ESE. } \frac{1}{2} \text{ E. } 104,5 \text{ miles.} \end{array} \right.$

QUESTION III. *A ship bound to a port bearing NNE. $\frac{1}{2}$ E. must double a cape to the eastward: Now she having run on her larboard tack 15 leagues within 6 points of the wind then at N. b. E. the port bore NW. b. W. $\frac{1}{4}$ W.: Required how near the wind she must lie on her starboard tack, and the distance of the port at each time of setting it?*

Here A is the place of the ship at first, B the port bound to; AC is the run on the larb. tack, and CB that on the starb. tack.

ANSWER $\left\{ \begin{array}{l} \text{The distance AB from the port is } 10,08 \text{ miles.} \\ \text{The run CB is } 11,61 \text{ miles, and } 6\frac{1}{4} \text{ points from the wind.} \end{array} \right.$

QUESTION IV. *A ship being bound to a port bearing SSE. and directly to windward, having run on her larboard tacks $83\frac{1}{4}$ miles within $6\frac{3}{4}$ points of the wind; on tacking about falls in with a rock at the same distance from her port: What course must she run on her starboard tacks, how near the wind, and what was the port's distance at first?*

Here the side AC = CB; therefore $\angle B = \angle BAC = 6\frac{3}{4}$ points.

Hence $\angle C = 2\frac{1}{2}$ pts. Also $\angle B = \angle BAN = 6\frac{3}{4}$ pts. Therefore $\angle NAn = 7\frac{1}{4}$ points.

ANSWER $\left\{ \begin{array}{l} \text{Starb. course E. b. N. } \frac{1}{4} \text{ E. } 6\frac{3}{4} \text{ points from the wind.} \\ \text{The port's dist. at first was } 40,47 \text{ miles.} \end{array} \right.$

QUESTION V. *A privateer lying by with the wind at NNE. sees a sloop on her starboard tacks that had just doubled a point 18 miles to the W. b. N.; the sloop run for her port within 6 points of the wind: The privateer gave chase at the rate of 8 knots an hour, and in 4 hours came up with her: Required the sloop's rate of sailing, and also the courses of both vessels?*

Draw BA to the E. b. S. and equal to 18 miles; on A with 32 m. = 8×4 , cut the rhumb BC drawn 6 points from the wind, at w: Then the

the privateer is first at A, sees the sloop at B, gives chase along the line AC, and takes the sloop at C; and Bo drawn parallel to AC shews the privateer's course from the north.

Here are known two sides, AB, AC, and the $\angle ABC = 13$ points.

ANSWER { The sloop sails NW. at the rate of 3,86 m. per hour $= \frac{BC}{4}$.
The privateer's course N. 63,12 W.

QUESTION VI. *Being within sight of my port bearing N. b. E. $\frac{1}{2}$ E. distant 18 miles, a fresh gale sprung up at NE.; then running 48 miles on my larboard tacks within 6 points of the wind, I tacked about: Required the course and distance to my port?*

From any point A draw AB, AC, parallel to *ao*, *an*, the N. b. E. $\frac{1}{2}$ E. and ESE. rhumbs, the latter being 6 points from the wind at NE.

Make AB = 18, AC = 48, and join BC. Then the ship at A first sees her port at B, and sailing from A to C on the larboard must go from C to B on the starboard tacks.

Here are known two sides, and the included angle A = $8\frac{1}{2}$ points. Therefore the solution will be as in art. 335.

ANSWER. The ship has to sail 52,89 miles on a course N. $47^{\circ} 42'$ W.

QUESTION VII. *A ship bound to a port met a sloop that had sailed from thence SSW. $\frac{1}{2}$ W. 325 miles, the wind being at N. b. E.; afterwards, the ship having plied on her larboard tack for three days, she met a vessel who had sailed on a direct course SE. b. E. $\frac{1}{2}$ E. 412 miles since she departed from that port: Required the ship's course and distance between her meeting those vessels, and how near the wind she lay?*

Here B is the port bound to, A and C are the points where the ship met the vessels, and AC the distance run; parallel to which, a line Bn being drawn will shew the course and distance from the wind.

ANSWER. The distance AC = 524,8 m. The course is N. $79^{\circ} 51'$ E. $6\frac{1}{4}$ points from the wind.

QUESTION VIII. *Being on my larboard tacks I met a snow that had sailed NE. b. N. 284 miles from the port I am bound to; and next day I met a brig who had sailed from thence 326 miles, with the wind, then at S. b. E. two points abaft the beam: Required my course and distance between the meeting those vessels; and how near the wind?*

Here B is the port, A and C the places of meeting.
There are known two sides and the contained angle.

ANSWER { The ship had sailed S. $64^{\circ} 06'$ E. $4\frac{3}{4}$ pts. from the wind.
The distance run was 125,9 miles.

QUESTION

QUESTION IX. *The wind at SW. and a ship plying to windward, after running 450 miles on her larboard tacks, and 450 on her starboard tacks, finds she has got 300 miles directly to windward: What were her courses, and how near the wind?*

From any point A draw $AB = 300$ miles, and parallel to the wind rhumb aw ; on A, B, with 450 miles describe arcs cutting in C; then the lines AC, CB, being drawn, will shew the distances run on each tack.

The point C is taken towards the NW. quarter as the ship leads with her larboard tacks; but had she led with her starboard, the point C must have been taken towards the SE. quarter.

The rhumbs ao , an , being drawn parallel to AC, CB, will shew the courses on each tack.

Here are the three sides given to find the angles: But two of the sides being equal, the solution is readily performed as in art. 358.

ANSWER { Course on larb. is N. $64^{\circ} 28'$ W. } $6\frac{1}{4}$ pts. from the wind.
 { Course on starb. is S. $25^{\circ} 32'$ E. }

QUESTION X. *A pyrate being in chase of a sloop 15 miles ahead to the WSW. both on the starboard tacks, the wind at NW.; the sloop finding she lost way tacked about for an island in the NW. quarter, 11 miles distant from her, and 13 from the pyrate: Required how near the wind must the sloop run, and whether the pyrate can continue the chase?*

ANSWER { The sloop's course is N. $10^{\circ} 05'$ E. 5 pts. from the wind.
 { The pyrate's course is N. $66^{\circ} 54'$ W. 2 pts. from the wind.
 Therefore he cannot continue the chase.

QUESTION XI. *Being on a NE. course with my larboard tacks, an island bore SW. distant 12 miles, and my port bore NNW.; the distance of the island and port is 40 miles: Now the wind being at NNW. $\frac{1}{2}$ W. and I can lie no nearer than $6\frac{1}{2}$ points: Required how far I must run on my present course before I tack about, and also the course and distance I have then to steer?*

In a SW. rhumb, from any point A take $AC = 12$ miles; and on C with a distance of 40 miles cut AB drawn parallel to the NNW. rhumb an ; now the rhumb ao being taken $6\frac{1}{2}$ points from the wind, thro' B draw BD parallel to ao , meeting CA continued in D.

Then A is the ship's place, C the island, B the port bound to; AD is the distance to run on the larboard tacks, and BD on the starboard.

In the triangle CBA there are known CA, CB, and $\angle CAB = \angle Can = 10$ pts.; then finding AB (352), in the triangle ABD one side and all the angles being known, the sides AD, DB, are found as in art. 349.

The $\angle D = Cao = 3$ pts. $\angle BAD = \angle Dan = 6$ pts. $\angle ABD = 7$ pts.

ANSWER { The distance run on the NE. course is 59,75 miles.
 { On the starb. she must run W. b. S. dist. 56,28 miles.

QUESTION

QUESTION XII. *A ship sailing close by a point sees two lighthouses, one 18 miles to the NE. b. E. the other 8 miles to the SE. b. S.; the ship is on her larboard tacks within $6\frac{1}{4}$ points of the wind, then at SE. b. E.: Required how far she must run to bring the lighthouses to bear in one line; and what will be the bearing and distances of them from the ship at that time?*

From any point c draw cA parallel to an the NE. b. E. rhumb, and equal to 18 miles, also draw CB parallel to ao the SE. b. S. rhumb, and equal to 8 miles; join AB , which produce till it meets in D the line CD drawn parallel to ar , a rhumb $6\frac{1}{4}$ points from the wind at SE.

Then c is the ship's place at first; A , B , are the lighthouses; CD the distance run to see them in one right line DBA ; then a rhumb as drawn parallel to DA shews their bearing at that time.

In the triangle ACB , knowing two sides and the included $\angle c = \angle nao = 8$ points; the other angles, and side AB is found as in art. 353.

In the triangle ACD , knowing CA , the $\angle ACD = \angle nar = 13\frac{1}{4}$ pts. also the $\angle A$ found before, the distance CD , AD , are found as in art. 349.

ANSWER { The ship runs on her larb. S. b. W. $\frac{1}{4}$ W. dist. 23,38 m.
Then the lighthouses bear N. $32^{\circ} 17'$ E.
The distance of A being 38,66 miles, and of B 18,96 miles.

QUESTION XIII. *A ship wants to reach on two tacks, a port bearing SW. b. S. but must double a point bearing S. b. E. the point being 25 miles to the NE. b. E. of the port; the ship can lie no nearer the wind now at SW. than $6\frac{1}{2}$ points: Required her course and distance on each tack?*

Take c the point, 25 miles to the NE. b. E. of B the port; thro' c draw CA parallel to Bn the S. b. E. rhumb, and its meeting with oB the SW. b. S. rhumb produced northward, gives A the ship's place; then AD and DB being drawn in the directions of the rhumbs Bs , Br , $6\frac{1}{2}$ points from the wind at w , shew the runs on each tack.

In the triangle ABC , there is known BC , $\angle BAC = \angle oBn = 4$ points, $\angle ABC = 2$ points, $\angle C = 10$ points; then AB is found as in art. 349.

In the triangle ABD , AB is now known, $\angle BAD = \angle oBs = 5\frac{1}{2}$ pts. $\angle ABD = \angle oBr = 7\frac{1}{2}$ points, $\angle D = 3$ points; hence AD , DB , are found as in art. 349.

ANSWER { Course on starb. is SSE. $\frac{1}{2}$ E. dist. 58,51 miles.
Course on larb. is NW. b. W. $\frac{1}{2}$ W. dist. 51,85 miles.

QUESTION XIV. *A privateer lying behind a low point 6 miles to the SW. b. W. sees a ship to the SSE. coming out of a port 18 miles distant from the point; the ship steered NW. with a brisk gale at SSW.; the privateer slipt his cable and gave chase within $6\frac{1}{2}$ points of the wind and takes her: How far had each run when they met?*

Take A , 6 miles to the NE. b. E. of c the point; from c with 18 miles cut AB drawn parallel to co the SSE. rhumb, and B is the port the ship

ship failed from; then AD drawn $6\frac{1}{2}$ points from the wind meeting BD drawn NW. the intersection D is the place where the privateer meets the ship.

In the triangle ACB, is given AC, CB, and $\angle CAB = \angle nco = 7$ pts. find AB.

Then in $\triangle ABD$, where $\angle DAB = \angle rco = 10\frac{1}{2}$ pts. $\angle DBA = 2$ pts. $\angle ADB = 3\frac{1}{2}$ points, find the sides AD, BD, as in art. 349.

ANSWER { The ship had failed NW. dist. 25,27 miles.
The privateer failed W. b. N. $\frac{1}{2}$ W. dist. 10,96 miles.

QUESTION XV. *A ship that can lie within 6 points of the wind sees a headland 21 miles to the NE. which she is to weather in order to reach an island 9 miles to windward thereof, the wind being at east: What course and how far must she go on each tack, she leading with the starboard?*

Draw BA = 21 m. to the SW. BC = 9 m. to the east, join AC; draw AD, CD, each 6 points from the wind; then A is the ship's place, B the headland, C the island; AD the run on the starboard tacks, and DC that of the larboard.

In the $\triangle ABC$, is given BA, BC, $\angle ABC = 12$ points; find the other $\angle$ s, and AC.

Then in the $\triangle ACD$, is known AC, and all the angles, to find AD, DC.

Thus $\angle D = 4$ pts.; $\angle DCA = \angle DCB + \angle BCA$; $\angle CAD = \angle BAD + \angle BAC$.

ANSWER { On the starb. she runs 39,19 miles on the NNE. rhumb.
On the larb. she runs 23,12 miles on the SSE. rhumb.

QUESTION XVI. *There is a certain port, which to sail into you must bring the port and a mill 4 miles to the east thereof, to bear due west; at the same time a beacon 5 miles to the NE. b. N. $\frac{1}{2}$ E. of the mill, bears N. b. E. $\frac{3}{4}$ E.; and then steer directly for the beacon and thence to the port: Required the best wind in the NW. quarter for a ship that goes equally well on both tacks, together with the distance she must run on each tack from the said situation to the port?*

In the W. rhumb take BC = 4 miles, and in the NE. b. N. $\frac{1}{2}$ E. rhumb take BD = 5 miles; join DC, and parallel to the N. b. E. $\frac{3}{4}$ E. rhumb Bn, draw DA meeting CB continued in A.

Then C is the port, B the mill, D the beacon, and A the ship's place.

In the $\triangle BAD$, is given BD and all the angles, to find AD.

In the $\triangle CBD$, is given BC, BD, and $\angle CBD$, to find the other angles and DC.

Draw the rhumb Bo parallel to DC; then the $\angle nBo$ being bisected will give the place of the wind as required.

ANSWER { She will run on her larb. N. b. E. $\frac{3}{4}$ E. dist. 4,105 miles.
And on her starboard S. $61^{\circ} 40'$ W. dist. 8,145 miles.
The best wind is that blowing from the NW. $\frac{1}{2}$ W. nearly.

QUESTION

QUESTION XVII. *A sloop in doubling a point directly to the east of her port, sees a lighthouse bearing NNW. $\frac{1}{2}$ W. which she knows lies NE. b. N. $\frac{1}{2}$ E. from the port, and is 10 miles to the NE. b. E. $\frac{3}{4}$ E. of a beacon bearing due north of her port: The wind is at W. b. N. $\frac{1}{2}$ W. and she can lie within 5 points: Required her distance on each tack, she leading with the larboard, and keeping close to the lighthouse when she tacks?*

Suppose D the beacon, make DC = 10 miles in the NE. b. E. $\frac{3}{4}$ E. rhumb, and C is the lighthouse; draw CB parallel to the NE. b. N. $\frac{1}{2}$ E. rhumb DN, and its intersection B with the S. rhumb DB is the port; thro' B and C, lines being drawn parallel to the E. and NNW. $\frac{1}{2}$ W. rhumbs, their intersection A is the place of the ship.

In the $\triangle CDB$ is given DC and all the angles; hence BC is found. (349)

In the $\triangle CBA$ there is known CB and all the angles; hence AC is found as in art. 349.

Here $\angle DBC = 3\frac{1}{2}$ points, $\angle BDC = 10\frac{1}{4}$ points, $\angle DCB = 2\frac{1}{4}$ points.

And $\angle ABC = 4\frac{1}{2}$ points, $\angle BAC = 5\frac{1}{2}$ points, $\angle ACB = 6$ points.

ANSWER { The distance on the larboard tacks is 12,49 miles.
The distance on the starboard tacks is 14,25 miles.

QUESTION XVIII. *A ship that can lie on either tack within 6 points of the wind then at ESE., having her starboard tacks aboard, sees her port directly to windward, and a headland that lies 6 miles to the NW. of her port, bore E. b. N.: Now she wanting to reach her port at two boards; required her course and distance on each, and also the bearing and distance of the headland when she tacks?*

Let C be the headland, and B, 6 miles to the SE. be the port; thro' C and B draw lines parallel to the E. b. N. and ESE. rhumbs, their intersection A is the ship's place; lines drawn thro' A and B parallel to the rhumbs, 6 points from the wind, will meet in C, the place where the ship must tack; draw DC, and this shews the position and distance of the headland from the ship when she tacks.

In the $\triangle ACB$ is given BC and all the angles; find AB = 8,979.

In the $\triangle ABD$ is known AB and all the angles; find AD, BD.

In the $\triangle BCD$ is known BC, BD, and $\angle CBD$; find the other angles and CD.

Here $\angle ACB = 11$ points, $\angle CAB = 3$ points, $\angle ABC = 2$ points.

The $\angle BAD = 6$ points, $\angle ABD = 6$ points, $\angle ADB = 4$ points, and $\angle CBD = 4$ points.

ANSWER { Ship runs on starboard 11,73 miles NE.
on larboard 11,73 miles S.
Headland bears when she tacks S. $29^{\circ} 32'$ W. dist. 8,607 m.

QUESTION XIX. *A ship on her starboard tacks passing by a point saw her port 8 miles to the E. b. N. and at the same time a cliff, which lay to the NW. b. W. of the port, bore N. b. E.; the ship on her starboard could lie within $6\frac{1}{2}$ points of the wind, then at NE. b. E. $\frac{1}{2}$ E., and within 7 points on the larboard; she proposes to reach the port on two boards: Required her course and distance on each, together with the bearing and distance of the cliff when she tacks about?*

Here the point c is taken for the cliff, in order to bring the figure within the limits; but if A, representing the ship's place, was taken at the centre, the construction would be more simple.

In the E. b. N. rhumb, take $ca = 8$ miles; draw ab parallel to the S. b. W. meeting cb drawn SE. b. E. in B, which is the port bound to; draw ba parallel to ac , meeting the S. b. W. rhumb in A, which is the ship's place; thro' A draw ad parallel to a rhumb $6\frac{1}{2}$ points from the wind, and thro' B draw bd parallel to a rhumb 7 points from the wind, their meeting D is the place where the ship is to tack; then dc being drawn shews the bearing and distance of the cliff from the ship when she tacks.

In the $\triangle CAB$, is given $BC = AB$ and all the angles; find $CA = 6,123$.

In the $\triangle ABD$, is given AB and all the angles; find AD , BD .

In the $\triangle ACD$, is known AC , AD , and $\angle CAD$; find the other angles and CD .

ANSWER { Course on starb. is N. b. W. distance 14,96 miles.
 { Course on larb. is SE. b. S. $\frac{1}{2}$ E. distance 16,97 miles.
 { The cliff on tacking bore S. $25^{\circ} 22'$ E. dist. 9,596 miles.

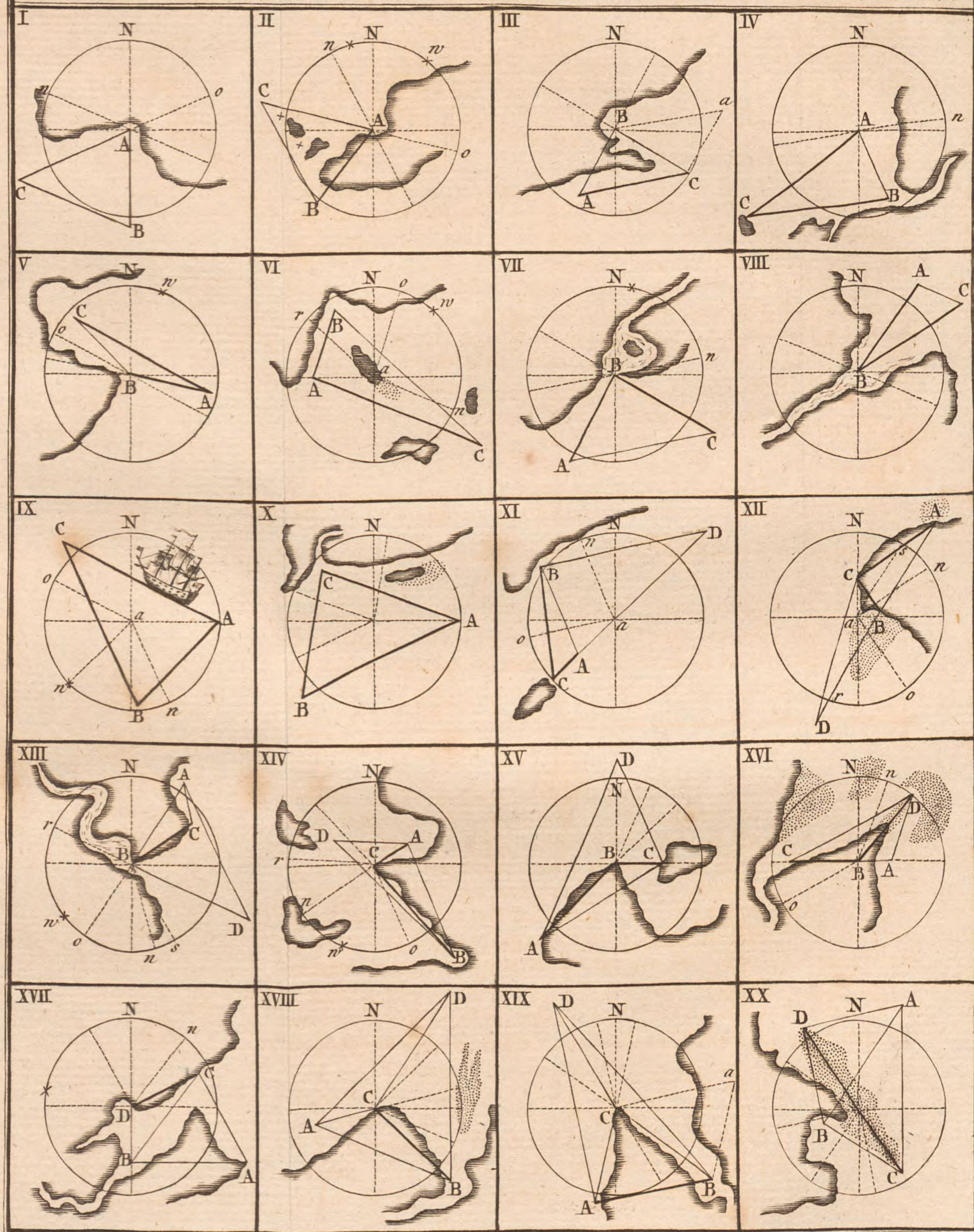
QUESTION XX. *A sloop at sea discovers two beacons at the extremities of a shoal, the one bearing W. b. S. and the other which bore S. was 9 miles to the SE. b. S. of the northern beacon; the port bound to lay NW. b. W. of one beacon, and S. b. E. of the other: Now the vessel can lie within $5\frac{1}{2}$ points of the wind then in the SW. quarter, and it being high water she can tack close to the southern beacon: Required the place of the wind, with the course and distance on each of two boards to gain her port; and also her bearing and distance from the port when she first saw the beacons?*

The construction and solution of this question being not much unlike the two last, they are here omitted to exercise the learner's skill.

ANSWER { The Wind is SW. b. W. $\frac{1}{2}$ W.
 { Course on starb. is S. distance 8,478 miles.
 { Course on larb. is NW. b. W. distance 4,87 miles.
 { Port bore S. $35^{\circ} 03'$ W. distance 7,05 miles.

SAILING ON A WIND.

P1. IV.



SECTION VIII.

Of sailing in currents.

706. A CURRENT or TIDE is a progressive motion of the water, causing all floating bodies to move that way, towards which the stream is directed.

The *setting of a tide*, or *current*, is that point of the compass towards which the waters run; and the *drift of a current* is the rate it runs per hour.

The setting and drift of the most remarkable tides and currents are pretty well known: But in unknown currents, the usual way to find the setting and drift, is thus.

Let three or four men take a boat a little way from the ship; and by a rope, fastened to the boat's stem, let down a heavy iron pot, or loaded kettle, into the sea to the depth of 80 or 100 fathoms, when it can be; whereby the boat will ride almost as steady as at anchor: Then heave the log, and the number of knots run out in half a minute will give the miles which the current runs per hour; and the bearing of the log shews the setting of the current.

707. A body moving in a current may be considered in three cases. Namely, Moving with, or the same way the current sets.

Moving against, or the contrary way the current sets.

Moving obliquely to the current's motion.

When a ship sails with the current, its velocity will be equal to the sum of its proper motion, and the current's drift.

When a ship sails against a current, its velocity will be equal to the difference of the current's drift and its own motion.

So that if the current drives stronger than the wind, the ship will drive astern, or lose way.

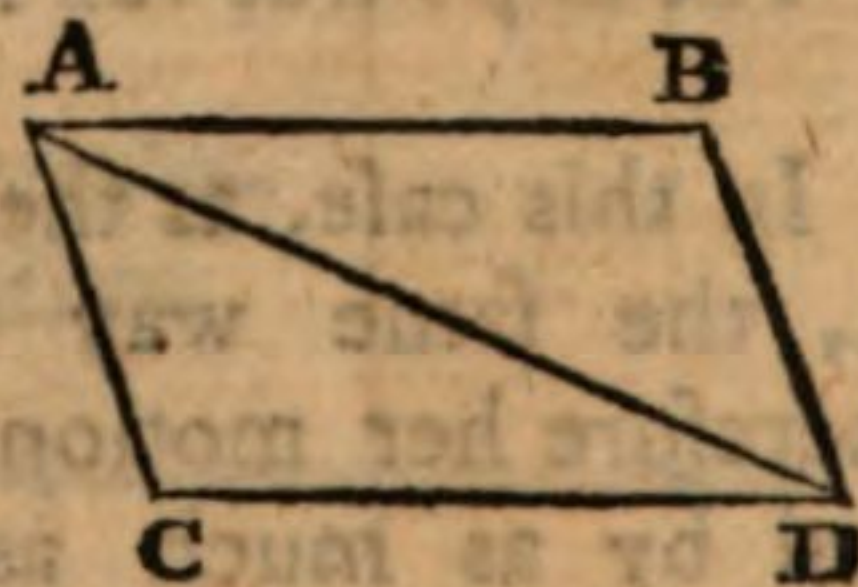
When the course set is oblique to the drift of the current, the ship's real course, or that made good, will be somewhere between that in which the ship endeavours to go, and the track in which the current tries to drive it: That is, it will always be along the diagonal of a parallelogram, wherein one side represents the ship's course set, and the other adjoining side is the current's drift.

For suppose ABCD be a parallelogram, whose diagonal is AD.

Now if the wind alone would drive the ship from A to B, in the same time as the current alone would drive it from A to C.

Then as the wind neither helps nor hinders the ship from coming towards the line CD, the current will bring it there in the same time as if the wind did not act.

And as the current neither helps nor hinders the ship from coming towards the line BD, the wind will bring it there in the same time as if the current did not act.



Therefore the ship must, at the end of that time, be found in both those lines; that is, in their meeting D.

Consequently the ship must have passed from A to D, in the diagonal AD.

708. When the ship's course and distance by account, and the setting and drift of the current are given; the true course and distance of the ship may be found either by working a traverse, in which the setting and drift of the current are used as a course and distance; or by a trigonometrical solution of the triangles forming the figure: Which is thus constructed.

From the centre of a circle draw the ship's proper course and distance, and the current's setting and drift; with these two lines form a parallelogram; and from the centre draw a diagonal, which will shew the ship's real course and distance.

709. It may frequently happen, that a ship is plying to windward across a tide's way. In such cases,

First construct the figure for the plying to windward.

Then with the course on each tack, and the setting of the current, form parallelograms, one of whose sides in each must be the ship's rate, and the other the current's drift.

And lines drawn to meet one another, from the centre and port bound to, parallel to the diagonals of those parallelograms, will shew the courses and distances the ship must run on each tack.

The figures referred to in this section are at the end in Plate V. wherein they are marked by the number of the question.

QUESTION I. *A ship sails E. 5 miles an hour, in a tide setting the same way 4 miles an hour: Required the ship's course, and the distance made good?*

The ship's motion is 5 m. E.

The current's motion is 4 m. E.

The ship's true run is 9 m. E.

In this case, as the ship sails from A, the same way the tide sets; therefore her motion will be quickened by as much as is the tide's motion.

QUESTION II. *A ship with a brisk gale sails SSW. at the rate of 9 miles an hour, in a current setting NNE. 2 miles an hour: Required the ship's course, and the distance made good?*

The ship's motion is SSW. 9 m.

The current's mot. is NNE. 2 m.

The ship's true run is SSW. 7 m.

Here as the ship sails in a contrary direction to the tide, its motion will be slower by as much as the tide acts against the motion given by the wind.

QUESTION

QUESTION III. *At 10 o'clock in the forenoon, a ship that was running four miles an hour, comes in sight of her port bearing ENE.; but finding, at three o'clock in the afternoon, that she had made no way, suspects a current, which on trial was found to set WSW. five miles an hour: What has been the course and real run of the ship during this time?*

In this case, had there been no current, the ship in 5 hours would have got a-head 20 miles from A to B: And had she been becalmed, she would have drove with the current 25 miles from A to c: Consequently the difference AD of these motions, is the way the ship has run; that is, she has drove a-stern 5 miles.

QUESTION IV. *A ship in doubling a cape meets a strong tide setting SE.; and after running SW. 18 miles by the log, the cape bore N. $\frac{3}{4}$ E.: Required the cape's distance, and the drift of the current?*

From A the cape, and centre of the horizon, draw AB in the SW. rhumb, and equal to 18 miles; thro' B draw BC parallel to the setting of the tide in the SE. rhumb A n; then AC drawn S. $\frac{3}{4}$ W. its intersection c with BC, shews the ship's place; and that she has run the line AC while the tide runs the length of BC, or A n.

In the triangle ABC is given AB and all the angles, to find AC, BC.

The $\angle B = 8$ points, $\angle BAC = 3\frac{1}{4}$ points, $\angle ACB = 4\frac{3}{4}$ points.

ANSWER { The ship has run 22,41 miles S. $\frac{3}{4}$ W.
The tide has run 13,35 miles SE.

QUESTION V. *A ship falling in with a current setting NNW. $\frac{1}{2}$ W. discovers a riff of rocks on the larboard, the eastern point whereof is 9 miles to the NE. b. N. $\frac{1}{2}$ E.; which can be weathered by steering E. b. S.: Required the distance the ship must run by the log, and also the drift of the current?*

Here A is the ship's place, c the eastern point of the rocks to be weathered, AB the course she must shape in order to run along the line AC, which is the diagonal of the parallelogram formed by the supposed way AB of the ship, and A n the current's drift.

ANSWER { The apparent run by the log is 10,76 miles.
And the drift of the current is 10,27 miles.

QUESTION VI. *A ship in crossing the mouth of a river, into which the tide set due east, sails from a buoy on the south side, NE. 10 miles, and then falls in with another buoy on the north side, distant from the first 15 miles: Required the ship's course, with the drift of the current?*

In

In the *SW.* rhumb take $BA = 10$ miles; on *A* with 15 miles cut the *E.* rhumb *BC* in *c*: Then *A* represents the southern buoy, *c* the northern one; *AB* is the ship supposed run, *AC* the real run, and *BC* the drift of the tide.

Here is given $AB = 10$, $AC = 15$, the $\angle B = 12$ points.

ANSWER { The ship's course is N. $61^{\circ} 52'$ E.
 { The tide's drift is 6,161 miles.

QUESTION VII. *At 11 o'clock in the evening having weathered a cape on my starboard, a lighthouse bore SW. b. S. and a strong tide was setting WSW. $\frac{1}{2}$ W. at the rate of $3\frac{1}{2}$ miles an hour; at 4 in the morning we passed over a sandy point $28\frac{1}{2}$ miles from the cape: Required the distance between the lighthouse and cape, also the course the ship has run?*

In the *ENE. $\frac{1}{2}$ E.* rhumb take $BA = 17\frac{1}{2}$ miles ($= 3\frac{1}{2} \times 5$) for the tide's drift. On *A* with $28\frac{1}{2}$ miles cut the *SW. b. S.* rhumb in *c* the sandy point; thro' *A* and *c*, lines drawn parallel to *BC*, *AB*, their intersection *D* is the lighthouse.

ANSWER { The distance *AD* or *BC* is 12,72 miles.
 { The ship's course along *AC* is S. $56^{\circ} 41'$ West.

QUESTION VIII. *A ship running south at the rate of 5 miles an hour, in 10 hours crosses a current which all that time was setting west at the rate of 3 miles an hour: Required the ship's true course and distance sailed?*

Here the ship is first supposed to be at *A*, her imaginary course is along the line *AB*; but her real course is along the line *AC*, the diagonal of the parallelogram, whose known sides are, $AB = 50$ miles ($= 10 \times 5$), and $BC = 30$ ($= 3 \times 10$).

ANSWER. The course is S. $30^{\circ} 58'$ E. distance 58,31 miles.

QUESTION IX. *Suppose a ship in 24 hours sails NE. 100 miles by the log, in a current setting E. b. S. $1\frac{3}{4}$ miles an hour: What is the course and distance made good?*

Draw *AB NE.* and equal to 100 miles, thro' *B* draw *BC* parallel to the *E. b. S.* rhumb, and make it 42 miles ($= 1\frac{3}{4} \times 24$); then draw *AC*, which shews the true run of the ship from *A*.

Here are given two sides *AB*, *BC*, and $\angle B = 11$ points.

ANSWER. The course is N. $60^{\circ} 49'$ E. distance 128,2 miles.

QUESTION X. *A ship departs from her port at 8 o'clock in the evening, and sails before the wind then at NNW. at the rate of $3\frac{1}{2}$ knots an hour, in a tide running at the same rate towards the eastward; and next day at noon she found herself 84 miles distant from her port: Required the ship's true course and the setting of the tide?*

In the NNW. rhumb take $BA = 56$ miles ($= 3\frac{1}{2} \times 16$ h.), on A with 84 miles, cut an arc described from B with 56 miles, their intersection c is the place the ship is come to, A being the port sailed from; AC the imaginary course before the wind, BC the run of the current, and AB the real run of the ship.

Here $BA = BC$, and the solution is as in art. 358.

ANSWER { The ship's true course is S. $63^{\circ} 55'$ E.
The setting of the current is N. $74^{\circ} 40'$ E.

QUESTION XI. *A ship in the evening departs for an island 46 miles to the WSW. but by a strong tide running to the southward, she found herself next morning on a shoal 65 miles from her departed port, and 34 miles from the island: Required the bearing of her port and the setting of the tide?*

Here A is the port sailed from, B the island bound to, c the shoal come to; the construction as in the last, and the solution as in art. 357.

ANSWER { The port bears N. $37^{\circ} 37'$ E.
The current set S. $4^{\circ} 56'$ E.

QUESTION XII. *A ship in latitude $41^{\circ} 18'$ N. is bound to a port in latitude $46^{\circ} 30'$ N. lying 258 miles to the west; where being arrived, finds by her dead reckoning that she has made 384 miles of northing, and 206 miles of westing: Required the setting and drift of the current that occasioned this difference?*

Here by the dead reckoning the ship should have gone from A to B; but she being arrived at the port c, the setting and drift of the current will be represented by the line BC; which is the hypotenuse of the triangle BFC, whose legs are the differences between the real and imaginary differences of latitude and departures.

For the current setting southward, will cause the ship to be longer getting to the northward, and thereby increase her account of northing; and by its setting westward, quickens the ship's motion that way more than her account shews.

ANSWER. The current's course is S. $35^{\circ} 50'$ W. and drift 88,82 m.

QUESTION

QUESTION XIII. *A ship from a place in latitude $37^{\circ} 40' N.$ sails SSW. distance 48 miles in 10 hours; then ESE. 72 miles in 14 hours; and has all the time been in a current setting SSW. $1\frac{1}{2}$ miles an hour: Required the ship's present latitude and departure, together with the direct course and distance she has sailed?*

As the current has run $1\frac{1}{2}$ miles an hour for 24 hours, its whole drift is 36 miles.

The best way of solving this question is to consider the current as another course and distance, and then with the three courses and distances form a traverse table, as shewn in art. 695.

TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
SSW.	48		44,3		18,4
ESE.	72		27,6	66,5	
SSW.	36		33,3		13,8
			105,2	66,5	32,2
				32,2	
				34,3	

The southing and easting the ship has made being thus known; the direct course and distance will be found as in art. 692.

Here the ship departs from A, and is come to C; AB being the diff. lat. and BC the departure.

ANSWER { The present lat. is $35^{\circ} 55' N.$ depart. 34,3 miles.
 { Direct course is S. $18^{\circ} 03' E.$ distance 110,7 miles.

QUESTION XIV. *Yesterday noon we were in latitude $28^{\circ} 14' N.$ and have sailed till this day noon these courses, viz. SSE. $\frac{1}{2} E.$ 24 miles; NE. b. E. $\frac{1}{2} E.$ 15 miles; ESE. $\frac{1}{4} E.$ 45 miles; and all this time we were in a current setting S. b. W. $1\frac{3}{4}$ miles an hour: Required the ship's present latitude, departure, direct course and distance?*

TRAVERSE TABLE.					
Courses.	D.	N.	S.	E.	W.
SSE. $\frac{1}{2} E.$	24		21,2	11,3	
NE. b. E. $\frac{1}{2} E.$	15	7,1		13,2	
ESE. $\frac{1}{4} E.$	45		15,2	42,4	
S. b. W.	42		41,2		8,2
		7,1	77,6	66,9	8,2
			7,1	8,2	
		D.lat.	70,5	58,7	Dep

Here the current being considered as a course, the traverse table gives the diff. lat. = 70,5 miles. and the depart. = 58,7 miles. And hence the direct course is S. $39^{\circ} 47' E.$ and the distance is 91,73 miles.

In any question, where there are given one or more courses and distances sailed, and also the setting and drift of the current, the work may be performed as above.

The reason of this is pretty evident; for as each course and distance is affected by the current; therefore instead of correcting them one by one, as shewn in most of the preceding questions, they may be all allowed for together, by making a course and distance of the quality and quantity of the current.

QUESTION

QUESTION XV. *At 8 o'clock in the evening, a ship sailed from her port on a SSW. course, 4 miles an hour; a strong tide was then setting between the S. and W.; and at 6 o'clock in the morning she passed by a rock 70 miles to the westward; and 60 miles to the southward of her port: Required the setting and drift, per hour, of the tide?*

With 60 miles as a diff. lat. and 70 miles as a departure, find the place of the rock at c; A being the place sailed from; in the SSW. rhumb take $AB = 40 (= 4 \times 10)$; draw BC, AC: Then AB is the supposed course, AC the real course, and BC the setting and drift of the tide.

In the $\triangle ADC$, is given AD, DC, $\angle D$; to find the $\angle$ s and $AC = 92,2$.

In the $\triangle ABC$, is known AC, AB, $\angle CAB$; to find $\angle$ s and $BC = 59,37$.

ANSWER. The tide sets S. 67,09 W. and runs 5,937 miles an hour.

QUESTION XVI. *At six o'clock in the forenoon a ship weathered a cape in latitude $46^{\circ} 32' N.$; and having run SE. b. S. 24 miles by the log in a current, found herself at noon in latitude $46^{\circ} 17' N.$ and the cape bore WNW.: Required the setting and drift of the current?*

Make AD = the diff. lat.; draw the departure DC, meeting the ESE. rhumb in c; draw AB, SE. b. S. and equal to 24 miles, and join BC.

Then A is the cape, c the place come to, AB the supposed run, BC the drift of the current, and AC the real run.

In the $\triangle ADC$, is given AD and the angles; to find $AC = 39,2$.

In the $\triangle ABC$, is known AB, AC, $\angle BAC$; to find the angles and $BC = 23,41$ m.

Then drawing the rhumb An parallel to BC, it shews the setting of the current.

ANSWER. The current sets N. $77^{\circ} 47' E.$ and runs 3,9 miles an hour.

QUESTION XVII. *A ship bound from Dover to Calais lying 21 miles to the SE. b. E. $\frac{1}{2} E.$; and the tide of flood setting NE. $\frac{1}{2} E.$ $2\frac{1}{2}$ miles an hour: Required the course she must steer, and the distance run by the log at the rate of 6 miles an hour, to reach her port?*

In the position of the SE. b. E. $\frac{1}{2} E.$ rhumb draw DC = 21 miles; and parallel to the NE. $\frac{1}{2} E.$ rhumb draw DE = $2\frac{1}{2}$ miles; on E with 6 miles cut DC in F; draw DB parallel to EF, meeting CB drawn parallel to DE.

Then D is Dover, c Calais; and the ship by trying to sail along the line DB, will be driven between it and the current in the line DC.

ANSWER. The ship must sail S. 39,14 E. and will run by the log 19,4 m.

QUESTION XVIII. Yesterday noon we were in latitude $42^{\circ} 20' N.$ and this day at noon find ourselves in latitude $41^{\circ} 10' N.$; by our account we have sailed SW. b. S. 189 miles, and all the time have been in a current setting NW.: Required the ship's direct course and distance, with the current's drift per hour?

Take $AD = 70$ miles, the diff. lat. draw AB parallel to an , the SW. b. S. rhumb, and equal to 189 miles; thro' B draw BC parallel to the NW. rhumb ao , meeting the departure DC , and join AC .

Then the ship from A supposes herself sailing along AB ; but by the action of the current is driven along AC .

In the $\triangle ADB$, is given AD , AB , $\angle BAD$; required the angles and $DB = 136,4$.

In the $\triangle DBC$, is known DB and the angles; to find $DC = 192$ and $BC = 123,1$.

In the $\triangle ADC$, is known AD , DC , $\angle ADC$; to find the angles and $AC = 204,4$.

ANSWER { The course is S. $69^{\circ} 58'$ W.; distance 204,4 miles.
The current's drift per hour is 5,13 miles.

QUESTION XIX. There are two ports which lie 270 miles to the north and south of one another; a ship sails from the northern port with her starboard tacks aboard within 72 degrees of the wind then at S. at the rate of 4 miles an hour, in a current setting south 2 miles an hour: Required her course and distance on each tack to reach the southern port?

From a point A in a line AD drawn S. $72^{\circ} E.$ draw $AB = 270$ miles to the south; thro' B draw BD parallel to Fn , a rhumb 72° from the wind; then was there no current, the ship must sail from A to D on the starboard, and from D to B on the larboard tacks.

Take $Fa = 2$ miles, draw ac , ac , parallel to FD , Fn , and make ac , ac , each of 4 miles; draw the diagonals Fc , Fc of those parallelograms; then thro' A and B , lines drawn parallel to Fc , Fc , meeting in C , will shew the run of the ship on each tack.

Here the triangles Fac , Fac , being congruous by construction, therefore the $\angle CAB (= \angle aFc)$ is equal to $\angle CBA (= \angle aFc)$.

Now in the triangle aFc , is given aF , ac , $\angle Fac = 108^{\circ}$; from whence the other angles are known; viz. $\angle aFc = 49^{\circ} 37'$.

Then in the triangle ABC , is known the side AB , and all the angles, whence the sides AC and CB are easily found.

ANSWER { The course on starb. is S. $49^{\circ} 37'$ E. distance 208,4 miles.
The course on larb. is S. $49^{\circ} 37'$ W. distance 208,4 miles.

QUESTION

QUESTION XX. *A ship that makes her way good within $6\frac{1}{2}$ points of the wind, is bound to a port bearing SW. b. S. $\frac{1}{4}$ W. distant 476 miles: Now the wind being at S. b. W. a current setting S. b. E. $2\frac{3}{4}$ miles an hour, and the ship sailing $7\frac{1}{2}$ miles an hour: Required the course and distance she must sail on her starboard and larboard tacks to gain the port?*

In the SW. b. S. $\frac{1}{4}$ W. rhumb, take $AB = 476$ miles; thro' A and B draw the lines AD, BD, in the directions of rhumbs $6\frac{1}{2}$ points from the wind, at S. b. W.; then, was there no current, the ship would sail on the lines AD, DB.

With the run of the current $aA = 2\frac{3}{4}$, and the run of the ship $7\frac{1}{2}$ miles an hour, taken in rhumbs A c, A d, $6\frac{1}{2}$ points from the wind, compleat the parallelograms, whose diagonals a c, a d, shew the courses the ship will move in, with the compound motions of the current's and ship's runs.

Then AC, BC, drawn parallel to a d, a c, will shew the run of the ship on the starboard and larboard tacks.

In the $\triangle A a d$ are given A a, A d, $\angle a A d$; to find the $\angle d a A = 37^\circ 41'$.

In the $\triangle A a c$ are given A a, A c, $\angle a A c$; to find the $\angle c a A = 74^\circ 54'$.

Then $\angle C A n = \angle d a A$; $\angle o A n = \angle c a A$; and $\angle B A C = (\angle B A n + \angle C A n) = 85^\circ 30'$.

Also $\angle n A o - \angle n A B = \angle B A o = \angle A B C = 27^\circ 05'$. (183)

Then in the triangle ACB, there is known one side AC, and all the angles; by which the sides AC, CB, may be found.

ANSWER { The course on the starb. is S. $48^\circ 56'$ E. dist. 234,7 miles.
The course on the larb. is S. $63^\circ 39'$ W. dist. 514 miles.

Most of the Questions in the three preceding sections, altho' not of such common use at sea, as those in sections the IVth and Vth, yet have they their uses on various occasions, as will evidently appear from many of the questions themselves: But there is another excellent use to be derived from their solution, that does not appear at first sight so evident to learners, which is, the furnishing them with an agreeable opportunity of exercising their talents in the application of Plane Trigonometry: For it should be well observed, that as all the operations relating to sailing depend on the principles of Trigonometry, so the persons, to whom these principles are the most familiar, will with the greatest readiness not only apply them to the cases of sailing, but also see more clearly the reason of every step they shall find themselves necessitated to take: And as a farther exercise for the understandings of those who are desirous of extending their notions this way, it has been thought proper to annex the Questions in the following section with their solutions.

SECTION IX.

710.

A collection of practical questions.

The figures belonging to the questions in this section are in Pl. VI, and numbered the same as the questions.

QUESTION I. *A ship in latitude $47^{\circ} 30' N.$ is bound to a port in latitude $42^{\circ} 00' N.$ and 120 miles to the west, proposes to reach her port by running equal distances on each tack, the first to be on the meridian: What must the course be on the second tack, and how far on each?*

SOLUTION. With the given difference of latitude $= 330$, and the departure $= 120$, construct the triangle ABC; from E, the middle of AC, draw ED at right angles to AC: Then drawing DC, the lines AD, DC, will be the distances the ship must run on each tack.

For ADC is by construction an isosceles triangle. (193)

In the triangle ABC, find the angles (341), $\angle A = 19^{\circ} 59' = \angle ACD$; the $\angle ACB - \angle ACD = \angle DCB = 50^{\circ} 02'$; and $90^{\circ} - \angle DCB = \angle BDC = 39^{\circ} 58'$.

In the triangle CBD, find (340) $DC = 186,8$.

ANSWER. The first course is S., the 2d S. $39^{\circ} 58' W.$; and the dist. on each tack 186,8 miles.

QUESTION II. *A ship having sailed NE. b. E. from a port in latitude $42^{\circ} 18' N.$, met a sloop who had sailed from a port in the same latitude, lying 92 miles to the west of the ship's port: The sum of their distances made 159 miles: Required their respective courses and distances?*

SOLUTION. In an east and west line take $BA = 92$ m., from B draw on the NE. b. E. rhumb $BC = 159$ m. join CA; then ED, drawn at right angles to CA from E the middle, gives D, so that $DA = DC$. (193)

In the triangle ABC, find (343) the $\angle BAC = 114^{\circ} 27'$, and $\angle ACD = \angle CAD = 31^{\circ} 47'$.

Then $\angle BAC - \angle CAD = \angle BAD = 82^{\circ} 40'$; hence $\angle BDA = 63^{\circ} 25'$.

In the triangle BAD, find (340) $BD = 101,9$ miles, and $AD = 57,7$ m.

ANSWER. The ship sail'd NE. b. N. 101,9 miles, and the sloop sailed N. $7^{\circ} 20' W.$ 57,7 miles.

QUESTION III. *Two ships, A, B, sail from one road, their courses making an angle of $50^{\circ} 00'$; A sails between the S. and W. 40 leagues, B sailing between the S. and E. 50 leagues, has got 15 leagues to the southward of A: Required the course of each ship, also the bearing, distance and departure from A to B?*

SOLUTION. With the given sides and included $\angle A$, construct the triangle ACB: On A, with 15 leagues, describe an arc at D, and from E, the middle of AB, with the radius EA, cut the former arc in D (213); draw the given diff. lat. AD, and the required departure DB: Then C is the port sailed from, A one ship's place, B the other's.

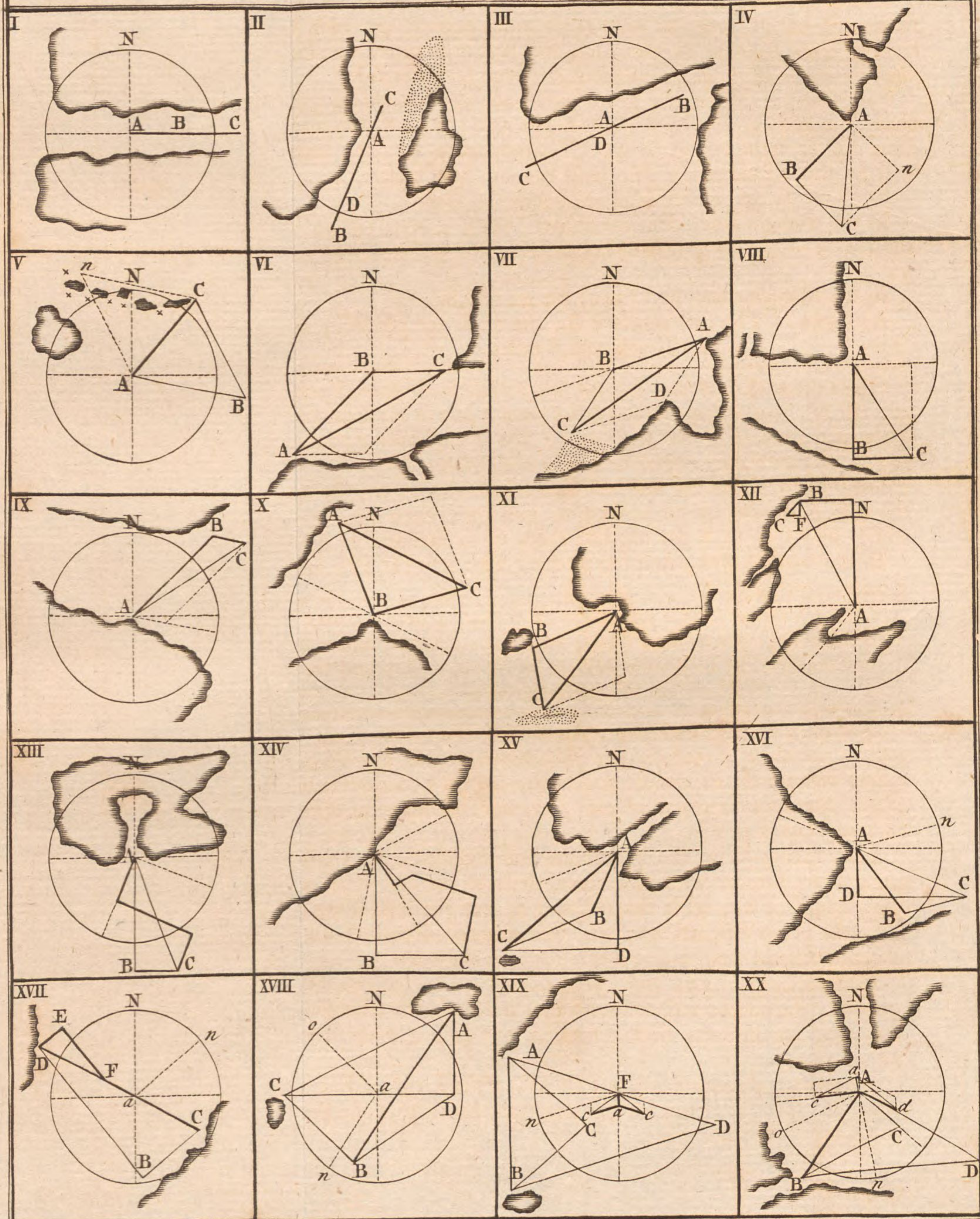
In the triangle ACB, find (343) the $\angle CAB = 78^{\circ} 24'$, and $\angle CBA = 51^{\circ} 56'$; the side AB will be found 39,1 miles. In the triangle ADB, where AB, AD, are known, find $\angle DBA = 22^{\circ} 34'$, $\angle DAB = 67^{\circ} 26'$, and $BD = 36,1$.

ANSWER. A's course is S. $34^{\circ} 10' W.$ B's is S. $15^{\circ} 10' E.$; B bears from A S. $67^{\circ} 26' E.$ departure BD is 36,1 m. the dist. AB is 39,1 miles.

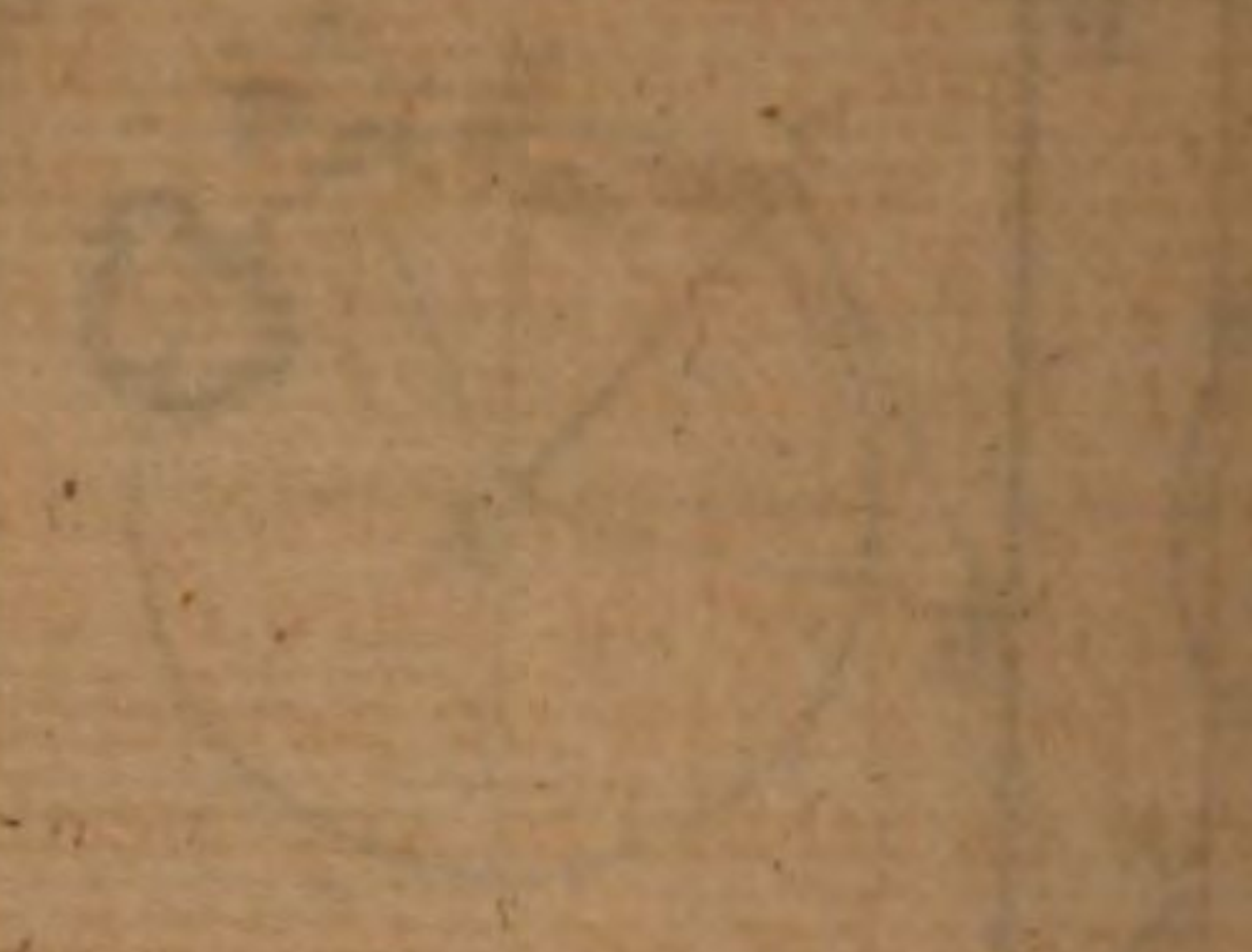
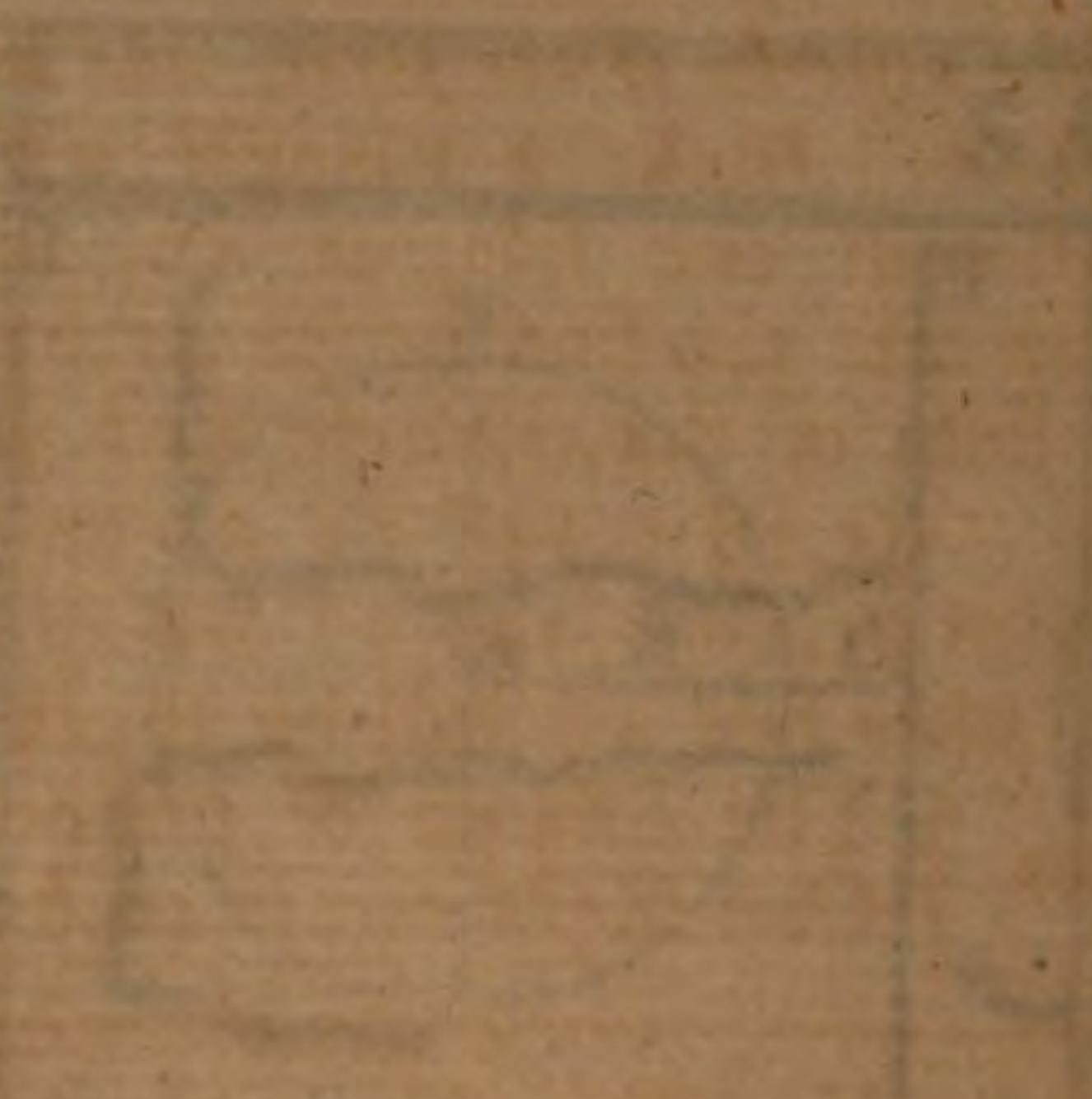
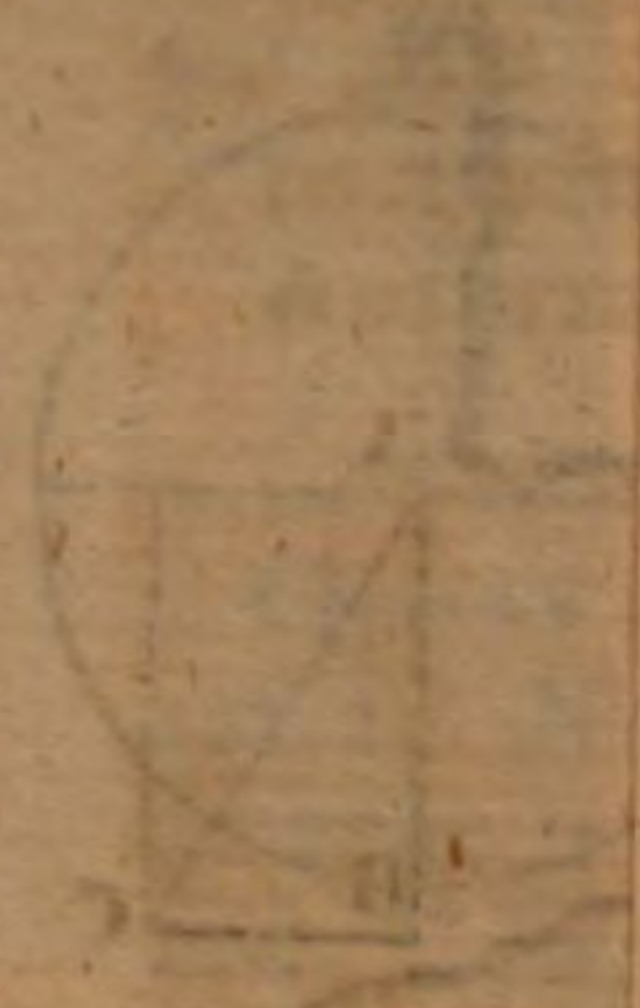
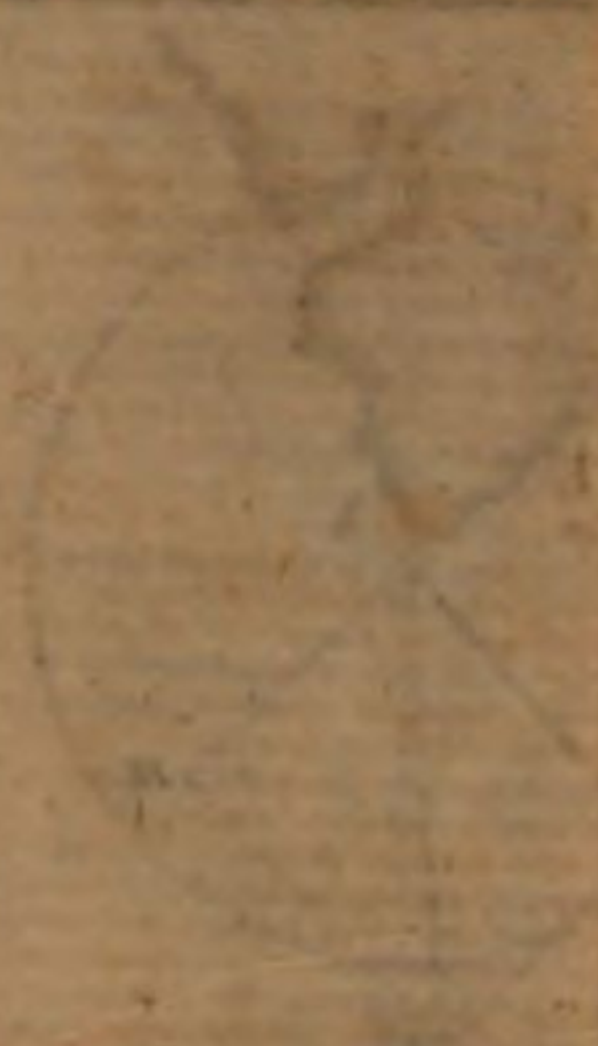
QUESTION

SAILING IN CURRENTS.

Pl.V.



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QUESTION IV. *From two ports bearing NW. b. N. and SE. b. S. two ships sail, the one NE. the other N. b. E.; they meet, and find that the sum of their distances added to the distance of the ports made 148 miles. Required the distance of the ports, and the run of each ship?*

SOLUTION. Make a triangle ADE equiangular to the triangle required, wherein one side, as AD, shall be of any assigned length, as 30, and by art. 340 find $DE = 41,61$; $AE = 23,57$; and the sum of the three sides of the triangle ADE will be 95,18: Then say,

As 95,18 : 148 :: AD = 30 : AC = 46,65.

And as 95,18 : 148 :: DE = 41,61 : CB = 64,70.

Then the other side AB will be 36,25 miles.

ANSWER { The distance of the ports is 36,25 miles.
One ship's run is 46,65 miles, the other's 64,7 miles.

QUESTION V. *Two ships meet at sea bound to two ports distant from one another 12 miles; Now if one sails NW. b. N. 6 miles an hour, and the other NE. 8 miles an hour, they will arrive at their respective ports at the same time: Required the distance each ship must run, and the bearing of those ports from one another?*

SOLUTION. With the courses and rates of sailing make the triangle ADE, A representing the place of meeting; parallel to DE draw AG = 12 miles; thro' G draw GC parallel to AD, meeting AE produced in C; thro' C draw CB parallel to AG, meeting AD produced in B; then B and C are the ports. For $AB : AC :: 6 : 8$; and $BC = 12 = AG$, BG being a parallelogram.

In the triangle ADE, knowing AD, AE, and $\angle A$, find $\angle D = 60^\circ 30'$, $\angle E = 40^\circ 45'$, and $DE = 9,015$ miles; then $DE : BC :: AE : AC = 10,65$; :: $AD : AB = 7,988$.

ANSWER { One runs NE. 10,65 miles; the other NW. b. N. 7,988 m.
C bears from B N. $85^\circ 45'$ E.

QUESTION VI. *A fleet of ships steering SW. b. S. 4 miles an hour, on seeing a sail, detached a cruiser, who gave chase SE. 5 hours at the rate of 7 miles an hour, comes up with and takes the chace (being a privateer); and after an hour's time spent in adjusting matters on board the prize, she steers for the fleet who still kept on the same course and rate: Required the course the cruiser must shape, and the distance she must run at 7 miles an hour, to join them?*

SOLUTION. Let C be the first place of the fleet, draw CD, SW. b. S. and CB, SE.; make $CB = 35 (= 7 \times 5)$, $CA = 24 (= 4 \times 6)$, and draw AB; then B is the place where the cruiser took the chace, and A the place where the fleet was when she left the chace: Make $AF = 4$, $FE = 7$, draw BD parallel to FE, and D is the place where the cruiser joined the fleet.

In the triangle ACB, find $\angle CAB = 63^\circ 25'$, and $\angle CBA = 37^\circ 49'$, and $AB = 38,39$. Then (181) $\angle FAE = 116^\circ 35'$. In the triangle FAE, find $\angle E = 30^\circ 44'$, and $\angle F = 32^\circ 41'$.

In the triangle ADB, similar to AFE, find $BD = 63,58$ miles.

ANSWER. The cruiser must steer S. $66^\circ 26'$ W, and run 63,58 miles.

QUESTION

QUESTION VII. *A ship on a WSW. course can sail from the port A to the port B in 6 days: But sailing at the same rate by the log on a NE. b. N. course, she goes from B to A in 3 days, a current all the way between the ports setting east, half a mile an hour: Required her dead reckoning outwards and homewards, also the bearing and distance of A from B?*

SOLUTION. In the 9 days outward and homeward bound, the current runs at $\frac{1}{2}$ mile an hour, 108 miles east, that is 72 m. for outwards, and 36 homewards. In an east and west line take $AD = 36$, $Dd = 72$; thro' A draw a WSW. rhumb, and thro' d draw a NE. b. N. and SW. b. S. rhumb, continued to cut the former in E: Thro' D, E, draw parallels to dE , dA , cutting in B; join AB, and draw BF parallel to EA, meeting dA produced in F; then A and B represent the two ports, AE the outward dead reckoning, BD the homeward, and AB the true distance.

For if $AF = BE = Dd = 72$ is the drift of the current in the outward account, and the course shaped is along AE, the ship must run between AF and AE: Also if $BC = AD = 36$ is the current's drift homeward, and the course shaped is along BD, the ship must run between BG and BD: But AB is the only common diagonal to the parallelograms FE and DC; consequently A and B are the ports.

In the triangle A d E, find (340) $AE = 161,6$ and $Ed = BD = 74,39$ m.

In the triangle ADB, find (343) $\angle DAB = 39^\circ 39'$, and $\angle DBA = 17^\circ 36'$. Also (340) find $AB = 99,04$.

ANSWER { The deadreckoning outw. = 161,6 m. homew. = 74,39 m.
The true course is S. $21^\circ 21'$ W.; distance 99,04 miles.

QUESTION VIII. *A ship after doubling a cape and sailing NE. b. N. 45 miles, receives in the night considerable damage from a storm; she then bore directly towards a lighthouse lying 24 miles to the NW. of the cape, and having run 40 miles, and the day breaking, she discovers a port 42 miles to the north of the cape: What was her course and distance to that port?*

SOLUTION. Draw AD NE. b. N. 45 m.; AB N. 42 m.; AC NW. 24 miles; join DC, make $DE = 40$ m. and draw AE, EB; then A is the cape, C the lighthouse, and B the port.

In the triangle CAD with the given sides and included angle A, find the $\angle C = 70^\circ 58\frac{1}{2}'$, $\angle D = 30^\circ 16\frac{1}{2}'$, and the side $CD = 46,69$ miles.

In the triangle ADE with the given sides and included angle D, find the $\angle DEA = 87^\circ 08'$, $\angle DAE = 62^\circ 36'$, and $AE = 22,71$ miles.

In the triangle BAE with the known sides AB, AE, and included $\angle EAB$, find $\angle BEA = 124^\circ 47'$, $\angle B = 26^\circ 22'$, and $EB = 24,67$ miles.

ANSWER { The course from E to B is N. $26^\circ 22'$ E.
And the distance EB is 24,67 miles.

QUESTION IX. *A ship running at the rate of $4\frac{1}{2}$ miles an hour, with the wind, then at E. b. N. blowing two points abaft the beam; at 5 in the evening, being 2 leagues to the W. b. S. of a headland, she met the tide of flood setting SSW. at the rate of $1\frac{3}{4}$ miles an hour; and at 9 that evening, a lighthouse, which lay to the NNE. $\frac{1}{2}$ E. of the headland, bore ENE. $\frac{3}{4}$ E.: Required the ship's course and her distance from the lighthouse?*

SOLUTION. From 5 to 9 is 4 hours, in which time the ship runs 18 miles, and the tide 7 miles: Also 2 points abaft the beam, or 10 points from the wind, is NW. b. N.

Suppose the ship at A; then in the E. b. N. rhumb take $AE = 6$, and E is the headland; in the NW. b. N. take $AB = 18$; thro' B draw BC parallel to the SSW. rhumb, and equal to 7, join CA, CE; thro' E draw a NNE. $\frac{1}{2}$ E. rhumb, meeting in D a ENE. $\frac{3}{4}$ E. rhumb drawn from C: Then C is the ship's place at last, AC her real run, and D the place of the lighthouse.

In the triangle ABC, where two sides, AB, BC, and the included $\angle B$, are known; find $\angle BCA = 101^\circ 19'$; $\angle BAC = 22^\circ 25'$, and the side $AC = 15,26$ miles.

In the triangle CAE, where are known $AE = 6$, $AC = 15,26$, $\angle CAE = 134^\circ 55'$; find $\angle AEC = 32^\circ 47'$, $\angle ACE = 12^\circ 18'$, and the side $CE = 19,94$ miles.

In the triangle CED, where are known $CE = 19,94$ m. $\angle D = 47^\circ 49'$, $\angle DCE = 35^\circ 36'$, and $\angle DEC = 96^\circ 35'$; the side ED will be found 15,67 miles, and the side $CD = 26,74$ miles.

ANSWER. The ship's true course is N. $56^\circ 10'$ W.; dist. from the lighthouse 26,74 miles.

QUESTION X. *Two ships departed from a port at the same time, after one had sailed SE. b. E. 40 miles, and the other SW. 50 miles, they were equally distant from a rock lying directly south of their port: Required their bearing and distance from the rock?*

SOLUTION. From A the port, draw AB SW. 50 miles, AC SE. b. E. 40 miles, join BC, and from F, the middle thereof, draw at right angles to BC, the line FD meeting the meridian in D, the place of the rock, and join DB, DC, which are equal by art. 193.

In the triangle BAC, where are known $AB = 50$, $AC = 40$, $\angle BAC = 101^\circ 15'$; find $\angle ACB = 44^\circ 35'$, $\angle ABC = 34^\circ 10'$, and $BC = 69,86$ miles.

In the triangle AEC, where are known $AC = 40$, $\angle EAC = 56^\circ 15'$, $\angle ACE = 44^\circ 35'$, $\angle AEC = 79^\circ 10'$; find $EC = 33,86$ miles.

Then $CF = (\frac{1}{2} BC) - EC = FE = 1,07$.

In the right angled triangle FED, where are known $FE = 1,07$, and $\angle FED = 79^\circ 10'$; find the side $DF = 5,591$.

In the right angled triangle DFC, where $DF = 5,591$, $FC = 34,93$; find the $\angle FDC = 80^\circ 54'$, and $DC = 35,38$ miles.

ANSWER { The ship at B is 35,38 miles to the S. $88^\circ 16'$ W. the rock.
The ship at C is 35,38 miles to the N. $70^\circ 04'$ E. the rock.

QUESTION

QUESTION XI. *Sailing E. b. S. with a brisk gale $7\frac{1}{2}$ knots an hour, we saw two islands, one bearing SE. b. S. the other E. b. N.; the tide was then running SW. b. W. $2\frac{1}{2}$ miles an hour: Two hours after, the first island bore W. b. S. and the other NW. b. N.: Required the ship's course and distance, together with the bearing and distance of those islands from one another?*

SOLUTION. In an E. b. S. rhumb, take $AC = 15$ miles, ($= 7\frac{1}{2}$ m. $\times 2$); thro' A draw AB, AE, parallel to the E. b. N. and SE. b. S. rhumbs; draw CD SW. b. S. and equal to 5 miles, which the tide runs in two hours; thro' D lines being drawn parallel to the NW. b. N. and W. b. S. rhumbs, their intersections with AB, AE, give E, the place of one island, and B, the place of the other; join AD, BE.

In the triangle ADC, where $AC = 15$, $DC = 5$, and $\angle ACD = 45^\circ 00'$; find the $\angle CDA = 117^\circ 52'$, $\angle CAD = 17^\circ 08'$, and $AD = 12$ miles.

Now as ED is parallel to AB, and BD parallel to AE, therefore ABDE is a parallelogram; and so $AB = ED$, $AE = BD$.

In the triangle AED, where $AD = 12$ miles, $\angle AED = 112^\circ 30'$, $\angle DAE = 27^\circ 52'$, and $\angle ADE = 39^\circ 38'$; find $AE = 8,286$ miles, and $ED = 6,072$ miles.

In the triangle ABE, where $AE = 8,286$ miles, $AB = 6,072$ miles, and $\angle EAB = 67^\circ 30'$; find $\angle ABE = 69^\circ 15'$, the $\angle AEB = 43^\circ 15'$, and the side $BE = 8,186$ miles.

ANSWER { The ship's course was S. $61^\circ 37'$ E. distance 12 miles.
The N. island bore from the S. isle, N. $9^\circ 30'$ E. dist. 8,186 m.

QUESTION XII. *Coming out of port into which the tide of flood was then setting, I saw two headlands; the northern one, which bore ENE. $\frac{1}{2}$ E. was known to be 15 miles to the NNE. $\frac{1}{2}$ E. of the other, which then bore S. b. E.: After running E. b. S. $\frac{1}{2}$ E. 24 miles by the log, the northern headland bore NW. and the other W. b. S.: Required the setting and drift of the tide?*

SOLUTION. In a NNE. $\frac{1}{2}$ E. rhumb take $AB = 15$ miles; thro' A draw AC N. b. W. and AD E. b. N.; also thro' B draw BC WSW. $\frac{1}{2}$ W. and BD SW.; then C, the intersection of AC, BC, is the ship's place at first, and D, the meeting of BD and AD, is the ship's place at last: From C draw an E. b. S. $\frac{1}{2}$ E. rhumb $CE = 24$ miles, and draw AD, ED.

In the triangle ABC, where $AB = 15$ miles, $\angle ACB = 95^\circ 38'$, and the $\angle CBA = 45^\circ 00'$; find $AC = 10,66$ miles.

In the triangle ABD, where $AB = 15$ miles, $\angle ADB = 56^\circ 15'$, and the $\angle ABD = 73^\circ 08'$; find $AD = 17,26$ miles.

In the right angled triangle CAD, where $AC = 10,66$, and $AD = 17,26$; find $\angle ACD = 58^\circ 19'$, $\angle ADC = 31^\circ 41'$, and $CD = 20,29$ m.

In the triangle CDE, where $CE = 24$, $CD = 20,29$, and $\angle DCE = 14^\circ 49'$; find $\angle CDE = 112,29$, $\angle CED = 52^\circ 42'$, and $DE = 6,522$ m.

ANSWER. The tide set S. $42^\circ 55'$ W. and its drift is 6,522 miles.

QUESTION

QUESTION XIII. *A ship running 5 knots an hour discovers Scilly lights bearing NE. b. N. distant 6 leagues, the flood tide being just made, and setting ENE. 2 miles an hour: Required what course she must steer, and how far by the log, to bring herself 5 leagues to the south of the Lizard, which lies 11 leagues to the E. b. N. $\frac{1}{2}$ E. of Scilly?*

SOLUTION. Draw SL E. b. N. $\frac{1}{2}$ E. 33 miles, LE S. 15 miles, and SA SW. b. S. 18 miles; join SE, AE: Draw AB ENE. 2 miles, and on B with BC = 5 miles cut AE in C, join BC; draw AD parallel to BC, and ED parallel to AB; then A represents the ship's place at first, S Scilly, L the Lizard, E the ship's place at last, and AD the rhumb and distance she must sail.

In the triangle SLE, where SL = 33 miles, LE = 15, and the $\angle SLE = 84^{\circ} 22'$; find $\angle LES = 70^{\circ} 18'$, $\angle LSE = 25^{\circ} 20'$, and SE = 34,89 m.

In the triangle ASE, where AS = 18, SE = 34,89, and the $\angle ASE = 104^{\circ} 02'$; find $\angle SAE = 51^{\circ} 59'$, $\angle SEA = 23^{\circ} 59'$, and AE = 42,96 m.

In the triangle ABC, where AB = 2, BC = 5, and $\angle BAC = 18^{\circ} 14'$; find $\angle C = 7^{\circ} 11'$.

Now in the triangle ADE, similar to the triangle ABC, are known AE = 42,96 miles, $\angle DAE = 7^{\circ} 11'$, $\angle AED = 18^{\circ} 14'$, and the $\angle D = 154^{\circ} 35'$; hence the side AD will be found = 31,32 miles.

ANSWER. The ship must sail S. $87^{\circ} 05'$ E. distance 31,32 miles.

QUESTION XIV. *At 6 o'clock in the evening a privateer saw a ship directly to windward bearing NE. about 3 leagues distance, they were both close hauled on their starboard tacks; the privateer having sailed 18 miles, at 9 o'clock the ship bore E. b. N. $\frac{1}{2}$ E.: Now the privateer finding he got a-head, would speak with the ship at 2 o'clock in the morning: Required at what rate the privateer must sail, and at what time tack about, keeping 6 points from the wind, supposing the other ship does not alter her course and rate of sailing?*

SOLUTION. Six points from the wind at NE. on starb. tacks is NNW.; then in a line AF parallel to a NNW. rhumb take AC = 18 m. draw AI NE. in which take AB = 9; also BG = 3, GI = 5, representing the times between 6 and 9, and 9 and 2 o'clock; draw BE parallel to AF, and thro' C draw an E. b. N. $\frac{1}{2}$ E. rhumb CD; join DG, draw IE parallel to DG; thro' E draw EF 6 points from the wind, and join EC, CB: Then the privateer tacking at F, will meet the ship at E.

In the triangle ABC, find $\angle ABC = 82^{\circ} 46'$, $\angle ACB = 29^{\circ} 44'$, and CB = 16,76.

In the triangle CBD, find BD = 12,04, and DC = 8,689.

Then BG : GI :: BD : DE = 20,07 miles the ship sails from 9 to 2.

In the triangle CDE, find $\angle C = 81^{\circ} 31'$, $\angle E = 25^{\circ} 21'$, and EC = 19,42 miles.

In the triangle CEF, find FE = 11,76, and FC = 25,87 miles.

Now FE $\div$ FC = 37,63 m., which run in 5 hours, is 7,12 m. an hour.

And FC at 7,12 m. per hour gives 3 h. 37 m. 48 f. after 9 o'clock.

ANSWER. The privateer must tack at 12 h. 37 m. 48 f. and sail 7,12 miles an hour.

QUESTION XV. Two ships steering between the S. and W. parted company in latitude $20^{\circ} 15' N.$ one going $2\frac{3}{4}$ points more westerly than the other; next day at noon they arrived at two ports in latitude $19^{\circ} 16' N.$ and distant 45 miles: Required the course and distance which each ship sailed after they parted?

SOLUTION. In an east and west line take $CB = 45$ miles; on CB describe (180) the segment CBA of a circle that shall contain an angle equal to $30^{\circ} 56' = 2\frac{3}{4}$ points; in the meridian take $BH = 59$ miles, the diff. lat.; thro' H draw HA parallel to CB , meeting the circle CBA in A ; draw AF parallel to HB , meeting CB produced in F , join AB , AC , and from E the centre of the circle CBA , draw EA , EB ; EG parallel to CB , and ED parallel to BH .

In the right angled triangle EBD , where $\angle DEB = (\angle CAB =) 30^{\circ} 56'$, and $DB = 22,5$ miles; find $ED = FG = 37,54$, and $EB = EA = 43,77$ m.

In the right angled triangle AEG ; find $\angle AEG = 29^{\circ} 22'$, and $EG = 38,15$.

In the right angled triangle AFB , where $AF = 59$ miles, $BF = DF (= EG) - DB = 15,65$; find $\angle BAF = 14^{\circ} 51'$, and $AB = 61,06$ miles.

In the right angled triangle AFC , where $AF = 59$, $CF = CB + BF = 60,65$ miles, and $\angle CAF = 45^{\circ} 47'$; find $AC = 84,62$ miles.

ANSWER { The course of one ship is S. $14^{\circ} 51'$ W. dist. 61,06 miles.
The course of the other is S. $45^{\circ} 47'$ W. dist. 84,62 miles.

QUESTION XVI. Two ships, A and B, both going at the rate of 6 knots an hour, parted company in the latitude of $45^{\circ} N.$ A steering in the NE. and B in the NW. quarter; next day at noon they both arrived at their ports, A in lat. $45^{\circ} 58' N.$ B in lat. $45^{\circ} 36' N.$ and the sum of their departures was 64 miles: At what hour did they part, and what was the course and distance each ship had sailed?

SOLUTION. Make the departures $FG = 64$ miles, the diff. lat. $FB = 58$, and $GC = 36$ miles; draw BC , and from K , the middle of BC , draw at right angles to BC , HE , meeting FG in A , and BF produced in E ; join AC , AB ; then draw AH parallel to FB , and CD , BH parallel to FG , meeting AH in I and H .

In the right angled triangle BDC , where $DC = 64$, $DB = 22$; find $\angle DBC = 71^{\circ} 02'$, $\angle DCB = 18^{\circ} 58'$, and $BC = 67,69$ miles: Hence $BK = KC = 33,84$.

In the right angled triangle BKE , where $\angle E = 18^{\circ} 58'$, $\angle KBE = 71^{\circ} 02'$, and $KB = 33,84$ miles; find $BE = 104,1$: Hence $BE - BF = FE = 46,1$ miles.

In the right angled triangle EFA , find $FA = 15,84$ miles: Hence $AG = 48,16$.

In the right angled triangle AIC , where $AI = (GC =) 36$, $IC = 48,16$; find $\angle IAC = 53^{\circ} 13'$, and $AC = 60,13$ miles.

In the right angled triangle AHB , find $\angle BAH = 15^{\circ} 17'$.

Now AC or $AB = 60,13$ divided by 6 gives 10,02 hours = 10 h. 2 m. 12 f.

ANSWER { The ships parted at 1 h. 58 m. 48 f. in the morning.
A's course is N. $15^{\circ} 17'$ W. B's is N. $53^{\circ} 13'$ E.; dist. of each is 60,13 miles.

QUESTION

QUESTION XVII. *Passing by a rock lying off the mouth of a harbour whose breadth is 12 miles, the western point thereof bearing NNW. is 9 miles distant from the town; and the eastern point of the mouth bearing NE. b. N. is 6 miles from the town: Required the distance of the rock from the western and eastern points, and also from the town which bore N. b. E.?*

SOLUTION. With the three given sides, 12, 9, 6, having constructed a triangle where A and C are the western and eastern points of the harbour's mouth, and B the town; make the $\angle ACD = 3$ points, $= \angle$ between the bearings of A and B; also make the $\angle CAD = 2$ points $= \angle$ between the bearings of C and B; thro' ADC describe a circle; then the right line BDF being drawn will give in the circumference the point F, the place of the rock.

For the $\angle AFD = \angle ACD = 3$ points; and $\angle CFD = \angle CAD = 2$ pts. (212)

In the triangle ABC, find $\angle BAC = 28^\circ 57'$, the $\angle BCA = 46^\circ 33'$, and the $\angle ABC = 104^\circ 30'$.

In the triangle ACD, where $\angle ADC = 123^\circ 45'$, $\angle DCA = 3$ points, $\angle DAC = 2$ points, find $DA = 8,018$ miles.

In the triangle ADB, where $AB = 9$, $AD = 8,018$, and $\angle BAD = 6^\circ 27'$; find the $\angle ABD = 41^\circ 05\frac{1}{2}'$: Hence $\angle CBD = 63^\circ 24'$.

In the triangle ABF, find $AF = 10,65$ miles, and $FB = 15,64$ miles.

In the triangle FBC, find $FC = 14,02$ miles.

ANSWER. $FA = 10,65$, $FB = 15,64$, $FC = 14,02$ miles.

QUESTION XVIII. *At night casting anchor among a cluster of islands, I observed three lighthouses A, B, C; A bore NNE. B bore SSE. $\frac{1}{2}$ E. and C bore east; the distance from A to B is 94 miles, from B to C 78 miles, and from A to C is 59 miles: Required my distance from each lighthouse?*

SOLUTION. Let ABC be the triangle formed by the distances of the three lighthouses; on CB, CA, describe (180) segments of circles that shall contain the angles included between the bearings of C and B, and of C and A; and the intersection D of these circles, is the point where the ship cast anchor: Thro' the centres H, K, draw aE , bG , at right angles to CB, CA; and draw EB, EC; HB, HC; GC, GA; KC, KA; and join KH cutting CD in m .

Now because CD is a chord common to both circles, therefore HK bisects CD in m : Also, because $\angle CDB$ and $\angle CEB$ together are measured by half the circle (211); therefore $\angle CEB = 180^\circ - \angle CDB$; and for the same reason, the $\angle CGA = 180^\circ - \angle CDA$; therefore the $\angle$ s. CEB, CGA, are known; and (210) so are their equals $\angle CHa = 61^\circ 52\frac{1}{2}'$, $\angle CKb = 67^\circ 30'$.

In the triangle CAB, from the given sides find $\angle CAB = 55^\circ 48'$, $\angle CBA = 38^\circ 44'$, and the $\angle ACB = 85^\circ 28'$.

In the right angled triangle CaH , where $Ca = 39$ m. $\angle CHa = 61^\circ 52\frac{1}{2}'$; find $CH = 44,22$ miles.

In the right angled triangle CbK , where $Cb = 29\frac{1}{2}$ m. $\angle CKb = 67^\circ 30'$; find $CK = 31,93$ miles.

In the triangle KCH , where $KC = 31,93$, $CH = 44,22$, the $\angle KCH = 136^\circ 06'$ ($= \angle KCA + \angle ACB + \angle BCH$); find $\angle CKH = 25^\circ 40'$, and $\angle CHK = 18^\circ 14'$.

In the right angled triangle CHm , where $\angle CHm = 18^\circ 14'$, and $CH = 44,22$ m.; find $cm = 13,84$ miles, which doubled gives $CD = 27,68$ miles.

In the triangle ACD , where $CD = 27,68$ m. $\angle CAD = 25^\circ 40\frac{1}{2}'$, and $\angle ACD = 41^\circ 49\frac{1}{2}'$; find $AD = 42,6$ miles.

In the triangle ADB , where $AB = 94$ miles, $\angle BDA = 129^\circ 22\frac{1}{2}'$, $\angle DAB = 30^\circ 07\frac{1}{2}'$; find $DB = 61,03$ miles.

ANSWER. The distance from D to $\left\{ \begin{array}{l} A \text{ is } 42,6 \text{ miles.} \\ B \text{ is } 61,03 \text{ miles.} \\ C \text{ is } 27,68 \text{ miles.} \end{array} \right.$

QUESTION XIX. *In latitude $48^\circ 50' N$. we were attacked by a privateer, who upon receiving our broadside lay to, and we stood away NNW .; some time after the privateer bore away $NE. b. N$. and two hours after, he having by our estimation run 10 miles, was 7 miles directly east of us: Now by our account we had sailed 4 leagues since the action, and the tide all the time has run two miles an hour: Required the setting of the tide, the time the privateer lay to, our rate of sailing, and each ship's direct course and distance?*

SOLUTION. Suppose the action at A , then parallel to the NNW . and $NE. b. N$. rhumbs, draw $AB = 12$ m. $AC = 10$ m. and join BC ; thro' C draw $CD = 7$ miles due west; join BD , and in this line produced take $DI = 4$ miles the tide's drift in 2 hours; draw CF parallel and equal to DI ; thro' F draw a west line FG , meeting BI in I , and a meridian thro' A , in G ; and draw AF , AI , which represent the runs of the two ships, F being the place of the privateer when she was 7 miles east of the other ship then at I .

In the triangle ABC , where $AB = 12$, $AC = 10$, and $\angle BAC = 56^\circ 15'$; find $\angle ACB = 71^\circ 31\frac{1}{2}'$, $\angle ABC = 52^\circ 13\frac{1}{2}'$, and $BC = 10,52$ miles.

In the triangle BCD , where $BC = 10,52$ m. $CD = 7$ m. $\angle BCD = 15^\circ 16\frac{1}{2}'$ ($= 71^\circ 31\frac{1}{2}' - 56^\circ 15'$); find $\angle BDC = 138^\circ 40'$, $\angle DBC = 26^\circ 04'$, and $BD = 4,197$ miles, which is the tide's run while the privateer lay by.

In the triangle ACF , where $CA = 10$ m. $CF = 4$ m. and $\angle ACF = 82^\circ 25'$ ($= \angle DCF - \angle DCA$); find $\angle AFC = 74^\circ 52\frac{1}{2}'$, $\angle CAF = 22^\circ 42\frac{1}{2}'$, and $AF = 10,27$ miles, the distance sailed by the privateer.

In the right angled triangle AGF , where $AF = 10,27$, the $\angle FAG = (\angle GAC + \angle CAF =) 56^\circ 27\frac{1}{2}'$; find $AG = 5,675$, and $GF = 8,561$ miles.

In the right angled triangle AGI , where $AG = 5,675$, $GI = (GF - IF =) 1,561$; find $\angle GAI = 15^\circ 23'$, and $AI = 5,886$ miles.

Now $4,197$ m. divided by 2 m. per hour, gives $2,098$ h. $= 2$ h. 5 m. 52 f.

ANSWER $\left\{ \begin{array}{l} \text{The privateer lay by } 2 \text{ h. } 5 \text{ m. } 52 \text{ f. nearly.} \\ \text{The tide sets } S. 48^\circ 40' E. \\ \text{The privateer sailed } N. 56^\circ 27' E. \text{ distance } 10,27 \text{ miles.} \\ \text{The other ship sailed } N. 15^\circ 23' E. \text{ distance } 5,886 \text{ miles.} \end{array} \right.$

QUESTION

QUESTION XX. *From the ports A, B, C, lying under the same parallel of latitude, B being 60 miles, and C 160 miles to the east of A, three ships sail towards the NW. quarter and meet together, B having sailed two points, and C $3\frac{1}{2}$ points farther from the meridian than A had: Required the course and distance each ship has run?*

SOLUTION. In an east and west line CD, take CA = 160 m. AB = 60 m. make the angle ACE = 2 points = $22^{\circ} 30'$, the angle CAE = $1\frac{1}{2}$ points = $16^{\circ} 52'$ (175); and join EB.

Thro' the points AEC (163) describe a circle, cutting the line EB produced in H, and join HA, HC.

Now $\angle AHE = \angle ACE$; and $\angle BHC = \angle BAE$. (212)

Therefore ships sailing from A, B, C, and meeting in H, their course will differ by the quantities proposed.

For drawing a meridian HD, the angles DHA, DHB, DHC, will respectively represent the angles which the ships courses make with the meridian.

In the triangle ACE, where AC = 160 miles, $\angle EAC = 1\frac{1}{2}$ points, $\angle ECA = 2$ points, and $\angle AEC = 12\frac{1}{2}$ points; find the side EC = 73,21 miles.

In the triangle BCE, where BC = 100 m. CE = 73,21, and the included angle BCE = $22^{\circ} 30'$; find the $\angle CEB = 116^{\circ} 37'$, and $\angle CBE = 40^{\circ} 53'$.

Hence $\angle ABH = 40^{\circ} 53'$ (183); the $\angle HAB = 116^{\circ} 37'$.

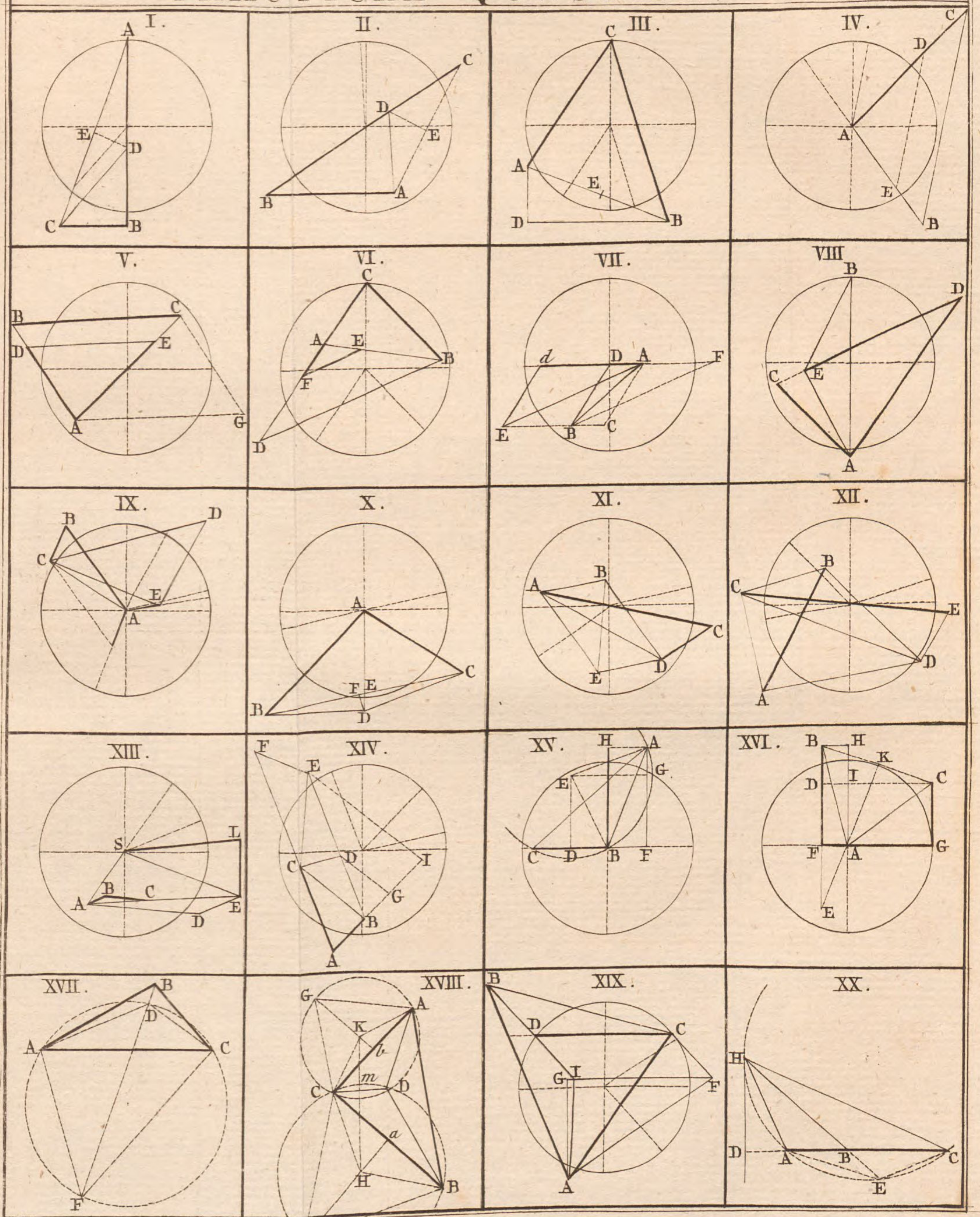
In the triangle AHB, where AB = 60, and all the angles are known, find HA = 102,6 miles, and AB = 140,2 miles.

In the triangle AHC where AC = 160, and all the angles are known, find HC = 225,5 miles.

ANSWER { A's course is N. $26^{\circ} 37'$ W. distance 102,6 miles.
B's course is N. 49 07 W. distance 140,2 miles.
C's course is N. 69 59 W. distance 225,5 miles.

PRACTICAL QUESTIONS.

Pl. VI.



T. Jefferys sculp.

711. A TRAVERSE TABLE

To every POINT and QUARTER POINT of the

COMPASS or HORIZON:

In FOUR PAGES.

AND ALSO

712. A TRAVERSE TABLE

To every DEGREE and QUARTER DEGREE of the

COMPASS or HORIZON:

In FORTY-FIVE PAGES.

Distance	0 Points						1 Point						2 Points						Distance
	$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0		$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0				
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.			
1	1,00	0,05	0,99	0,10	0,99	0,15	0,98	0,20	0,97	0,24	0,96	0,29	0,94	0,34	0,92	0,38	1		
2	2,00	0,10	1,99	0,20	1,98	0,29	1,96	0,39	1,94	0,49	1,91	0,58	1,88	0,67	1,85	0,77	2		
3	3,00	0,15	2,99	0,29	2,97	0,44	2,94	0,59	2,91	0,73	2,87	0,87	2,82	1,01	2,77	1,15	3		
4	4,00	0,20	3,98	0,39	3,96	0,59	3,92	0,78	3,88	0,97	3,83	1,16	3,77	1,35	3,70	1,53	4		
5	4,99	0,25	4,98	0,49	4,95	0,73	4,90	0,98	4,85	1,21	4,78	1,45	4,71	1,68	4,62	1,91	5		
6	5,99	0,29	5,97	0,59	5,93	0,88	5,89	1,17	5,82	1,46	5,74	1,74	5,65	2,02	5,54	2,30	6		
7	6,99	0,34	6,97	0,69	6,92	1,03	6,87	1,37	6,79	1,70	6,70	2,03	6,59	2,36	6,47	2,68	7		
8	7,99	0,39	7,96	0,78	7,91	1,17	7,85	1,56	7,76	1,94	7,66	2,32	7,53	2,69	7,39	3,06	8		
9	8,99	0,44	8,96	0,88	8,90	1,32	8,83	1,76	8,73	2,19	8,61	2,61	8,47	3,03	8,32	3,44	9		
10	9,99	0,49	9,95	0,98	9,89	1,47	9,81	1,95	9,70	2,43	9,57	2,90	9,42	3,37	9,24	3,83	10		
11	10,99	0,54	10,95	1,08	10,88	1,61	10,79	2,15	10,67	2,67	10,53	3,19	10,36	3,71	10,16	4,21	11		
12	11,99	0,59	11,94	1,18	11,87	1,76	11,77	2,34	11,64	2,92	11,48	3,48	11,30	4,04	11,09	4,59	12		
13	12,98	0,64	12,94	1,27	12,86	1,91	12,75	2,54	12,61	3,16	12,44	3,77	12,24	4,38	12,01	4,97	13		
14	13,98	0,69	13,93	1,37	13,85	2,05	13,73	2,73	13,58	3,40	13,40	4,06	13,18	4,72	12,94	5,36	14		
15	14,98	0,74	14,93	1,47	14,84	2,20	14,71	2,93	14,55	3,64	14,35	4,35	14,12	5,05	13,86	5,74	15		
16	15,98	0,79	15,92	1,57	15,83	2,35	15,69	3,12	15,52	3,89	15,31	4,64	15,06	5,39	14,78	6,12	16		
17	16,98	0,84	16,92	1,67	16,82	2,49	16,67	3,32	16,49	4,13	16,27	4,93	16,01	5,73	15,71	6,51	17		
18	17,98	0,88	17,91	1,76	17,81	2,64	17,65	3,51	17,46	4,37	17,22	5,22	16,95	6,06	16,63	6,89	18		
19	18,98	0,93	18,91	1,86	18,79	2,79	18,64	3,71	18,43	4,62	18,18	5,51	17,89	6,40	17,55	7,27	19		
20	19,98	0,98	19,90	1,96	19,78	2,93	19,62	3,90	19,40	4,86	19,14	5,81	18,83	6,74	18,48	7,65	20		
21	20,98	1,03	20,90	2,06	20,77	3,08	20,60	4,10	20,37	5,10	20,10	6,10	19,77	7,07	19,40	8,04	21		
22	21,97	1,08	21,89	2,16	21,76	3,23	21,58	4,29	21,34	5,35	21,05	6,39	20,71	7,41	20,33	8,42	22		
23	22,97	1,13	22,89	2,25	22,75	3,37	22,56	4,49	22,31	5,59	22,01	6,68	21,65	7,75	21,2	8,80	23		
24	23,97	1,18	23,88	2,35	23,74	3,52	23,54	4,68	23,28	5,83	22,97	6,97	22,60	8,08	22,17	9,18	24		
25	24,97	1,23	24,88	2,45	24,73	3,67	24,52	4,88	24,25	6,07	23,92	7,26	23,54	8,42	23,0	9,57	25		
26	25,97	1,28	25,87	2,55	25,72	3,81	25,50	5,07	25,22	6,32	24,88	7,55	24,48	8,76	24,02	9,95	26		
27	26,97	1,33	26,87	2,65	26,71	3,96	26,48	5,27	26,19	6,56	25,84	7,84	25,42	9,10	24,95	10,33	27		
28	27,97	1,37	27,87	2,74	27,70	4,11	27,46	5,46	27,16	6,80	26,79	8,13	26,36	9,43	25,87	10,72	28		
29	28,97	1,42	28,86	2,84	28,69	4,25	28,44	5,66	28,13	7,05	27,75	8,42	27,30	9,77	26,79	11,10	29		
30	29,96	1,47	29,85	2,94	29,67	4,40	29,42	5,85	29,10	7,29	28,71	8,71	28,25	10,11	27,72	11,48	30		
31	30,96	1,52	30,85	3,04	30,66	4,55	30,41	6,05	30,07	7,53	29,66	9,00	29,19	10,44	28,64	11,86	31		
32	31,96	1,57	31,84	3,14	31,65	4,70	31,39	6,24	31,04	7,77	30,62	9,29	30,13	10,78	29,56	12,25	32		
33	32,96	1,62	32,84	3,23	32,64	4,84	32,37	6,44	32,01	8,02	31,58	9,58	31,07	11,12	30,49	12,63	33		
34	33,96	1,67	33,84	3,33	33,63	4,99	33,35	6,63	32,98	8,26	32,54	9,87	32,01	11,45	31,41	13,01	34		
35	34,96	1,72	34,83	3,43	34,62	5,14	34,33	6,83	33,95	8,50	33,49	10,16	32,95	11,79	32,34	13,39	35		
36	35,96	1,77	35,83	3,53	35,61	5,28	35,31	7,02	34,92	8,75	34,45	10,45	33,90	12,13	33,26	13,78	36		
37	36,96	1,82	36,82	3,63	36,60	5,43	36,29	7,22	35,89	8,99	35,41	10,74	34,84	12,46	34,18	14,16	37		
38	37,95	1,87	37,82	3,72	37,59	5,58	37,27	7,41	36,86	9,23	36,36	11,03	35,78	12,80	35,11	14,54	38		
39	38,95	1,91	38,81	3,82	38,58	5,72	38,25	7,61	37,83	9,48	37,32	11,32	36,72	13,14	36,03	14,92	39		
40	39,95	1,96	39,81	3,92	39,57	5,87	39,23	7,80	38,80	9,72	38,28	11,61	37,66	13,48	36,96	15,31	40		
41	40,95	2,01	40,80	4,02	40,56	6,02	40,21	8,00	39,77	9,96	39,23	11,90	38,60	13,81	37,88	15,69	41		
42	41,95	2,06	41,80	4,12	41,54	6,16	41,19	8,19	40,74	10,20	40,19	12,19	39,54	14,15	38,80	16,07	42		
43	42,95	2,11	42,79	4,21	42,53	6,31	42,17	8,39	41,71	10,45	41,15	12,48	40,49	14,49	39,73	16,45	43		
44	43,95	2,16	43,79	4,31	43,52	6,46	43,16	8,58	42,68	10,69	42,11	12,77	41,43	14,83	40,65	16,84	44		
45	44,95	2,21	44,78	4,41	44,51	6,60	44,14	8,78	43,65	10,93	43,06	13,06	42,37	15,16	41,57	17,22	45		
46	45,95	2,26	45,78	4,51	45,50	6,75	45,12	8,97	44,62	11,18	44,02	13,35	43,31	15,50	42,50	17,6	46		
47	46,94	2,31	46,77	4,61	46,49	6,90	46,10	9,17	45,59	11,42	44,98	13,64	44,25	15,83	43,42	17,99	47		
48	47,94	2,36	47,77	4,70	47,48	7,04	47,08	9,37	46,56	11,66	45,93	13,93	45,19	16,17	44,35	18,37	48		
49	48,94	2,41	48,76	4,80	48,47	7,19	48,06	9,56	47,53	11,91	46,89	14,22	46,14	16,51	45,27	18,75	49		
50	49,94	2,45	49,76	4,90	49,46	7,34	49,04	9,75	48,50	12,15	47,85	14,5	47,08	16,84	46,19	19,13	50		
51	50,94	2,50	50,75	5,00	50,45	7,48	50,02	9,95	49,47	12,39	48,80	14,8	48,02	17,18	47,12	19,52	51		
52	51,94	2,55	51,75	5,10	51,44	7,63	51,00	10,15	50,44	12,63	49,76	15,09	48,96	17,52	48,04	19,90	52		
53	52,94	2,60	52,74	5,19	52,43	7,78	51,98	10,34	51,41	12,88	50,72	15,38	49,90	17,86	48,97	20,28	53		
54	53,94	2,65	53,74	5,29	53,41	7,92	52,96	10,54	52,38	13,12	51,67	15,67	50,84	18,19	49,89	20,66	54		
55	54,93	2,70	54,73	5,39	54,40	8,07	53,94	10,73	53,35	13,36	52,63	15,96	51,78	18,53	50,81	21,05	55		
56	55,93	2,75	55,73	5,49	55,39	8,22	54,92	10,92	54,32	13,61	53,59	16,25	52,73	18,87	51,74	21,43	56		
57	56,93	2,80	56,72	5,59	56,38	8,36	55,91	11,12	55,29	13,85	54,55	16,54	53,67	19,20	52,66	21,81	57		
58	57,93	2,85	57,72	5,68	57,37	8,51	56,89	11,31	56,26	14,09	55,50	16,84	54,61	19,54	53,59	22,20	58		
59	58,93	2,90	58,72	5,78	58,36	8,66	57,87	11,51	57,23	14,34	56,45	17,13	55,55	19,88	54,51	22,58	59		
60	59,93	2,94	59,71	5,88	59,35	8,80	58,85	11,71	58,20	14,58	57,42	17,42	56,49	20,21	55,43	22,96	60		
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance		
	$\frac{3}{4}$		$\frac{1}{2}$		$\frac{1}{4}$		0		$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0				
	7 Points						6 Points												

Distance	0 Points						1 Point						2 Points						Distance
	$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0		$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0				
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.			
61	60,93	2,99	60,71	5,98	60,34	8,95	59,83	11,90	59,17	14,82	58,37	17,71	57,43	20,55	56,36	23,34	61		
62	61,93	3,04	61,70	6,08	61,33	9,10	60,81	12,09	60,14	15,06	59,33	18,00	58,38	20,89	57,28	23,73	62		
63	62,92	3,09	62,70	6,17	62,32	9,24	61,79	12,29	61,11	15,31	60,29	18,29	59,32	21,22	58,21	24,11	63		
64	63,92	3,14	63,69	6,27	63,31	9,39	62,77	12,48	62,08	15,55	61,24	18,58	60,26	21,56	59,13	24,49	64		
65	64,92	3,19	64,69	6,37	64,30	9,54	63,75	12,68	63,05	15,79	62,20	18,87	61,20	21,90	60,05	24,87	65		
66	65,92	3,24	65,68	6,47	65,28	9,68	64,73	12,88	64,02	16,04	63,16	19,16	62,14	22,23	60,98	25,26	66		
67	66,92	3,29	66,68	6,57	66,27	9,83	65,71	13,07	64,99	16,28	64,11	19,45	63,08	22,57	61,90	25,64	67		
68	67,92	3,34	67,67	6,66	67,26	9,98	66,69	13,27	65,96	16,52	65,07	19,74	64,02	22,91	62,82	26,02	68		
69	68,92	3,39	68,67	6,76	68,25	10,12	67,67	13,46	66,93	16,77	66,03	20,03	64,97	23,24	63,75	26,40	69		
70	69,92	3,44	69,66	6,86	69,24	10,27	68,66	13,66	67,90	17,01	66,99	20,32	65,91	23,58	64,67	26,79	70		
71	70,92	3,48	70,66	6,96	70,23	10,42	69,64	13,85	68,87	17,25	67,94	20,61	66,8	23,92	65,60	27,17	71		
72	71,91	3,53	71,65	7,06	71,22	10,56	70,62	14,05	69,84	17,49	68,90	20,90	67,79	24,26	66,52	27,55	72		
73	72,91	3,58	72,65	7,15	72,21	10,71	71,60	14,24	70,81	17,74	69,86	21,19	68,73	24,59	67,44	27,94	73		
74	73,91	3,63	73,64	7,25	73,20	10,86	72,58	14,44	71,78	17,98	70,81	21,48	69,6	24,93	68,37	28,32	74		
75	74,91	3,68	74,64	7,35	74,19	11,00	73,56	14,63	72,75	18,22	71,77	21,77	70,62	25,27	69,29	28,70	75		
76	75,91	3,73	75,63	7,4	75,18	11,15	74,54	14,83	73,72	18,47	72,73	22,06	71,56	25,60	70,21	29,08	76		
77	76,91	3,78	76,63	7,55	76,17	11,30	75,52	15,02	74,69	18,71	73,68	22,35	72,50	25,94	71,14	29,47	77		
78	77,91	3,83	77,62	7,64	77,15	11,45	76,50	15,22	75,66	18,95	74,64	22,64	73,44	26,28	72,06	29,85	78		
79	78,91	3,88	78,62	7,74	78,14	11,59	77,48	15,41	76,63	19,20	75,60	22,93	74,38	26,61	72,99	30,23	79		
80	79,90	3,93	79,61	7,84	79,13	11,74	78,46	15,61	77,60	19,44	76,55	23,22	75,32	26,95	73,91	30,61	80		
81	80,90	3,98	80,61	7,94	80,12	11,88	79,44	15,80	78,57	19,68	77,51	23,51	76,27	27,29	74,83	31,00	81		
82	81,90	4,02	81,60	8,04	81,11	12,03	80,43	16,00	79,54	19,92	78,47	23,80	77,21	27,62	75,76	31,38	82		
83	82,90	4,07	82,60	8,14	82,10	12,18	81,41	16,19	80,51	20,17	79,43	24,09	78,15	27,96	76,68	31,76	83		
84	83,90	4,12	83,59	8,23	83,09	12,32	82,39	16,39	81,48	20,41	80,38	24,38	79,09	28,30	77,61	32,14	84		
85	84,90	4,17	84,59	8,33	84,08	12,47	83,37	16,58	82,45	20,65	81,34	24,67	80,03	28,63	78,53	32,53	85		
86	85,90	4,22	85,58	8,43	85,07	12,62	84,35	16,78	83,42	20,90	82,30	24,96	80,97	28,97	79,45	32,91	86		
87	86,90	4,27	86,58	8,53	86,06	12,76	85,33	16,97	84,39	21,14	83,2	25,21	81,91	29,31	80,38	33,29	87		
88	87,89	4,32	87,58	8,63	87,05	12,91	86,31	17,17	85,36	21,38	84,21	25,54	82,86	29,65	81,30	33,67	88		
89	88,89	4,37	88,57	8,72	88,04	13,06	87,29	17,36	86,33	21,62	85,17	25,83	83,80	29,98	82,23	34,06	89		
90	89,89	4,42	89,57	8,82	89,02	13,21	88,27	17,56	87,30	21,87	86,12	26,12	84,74	30,32	83,15	34,44	90		
91	90,89	4,47	90,56	8,92	90,01	13,3	89,25	17,75	88,27	22,11	87,08	26,41	85,68	30,66	84,07	34,82	91		
92	91,89	4,52	91,56	9,02	91,00	13,50	90,23	17,95	89,24	22,35	88,04	26,70	86,62	30,99	85,00	35,21	92		
93	92,89	4,56	92,55	9,12	91,99	13,65	91,21	18,14	90,21	22,60	89,00	27,00	87,56	31,33	85,92	35,59	93		
94	93,89	4,61	93,55	9,21	92,98	13,79	92,19	18,34	91,18	22,84	89,95	27,29	88,51	31,67	86,85	35,97	94		
95	94,89	4,66	94,54	9,31	93,97	13,94	93,18	18,54	92,15	23,08	90,91	27,58	89,45	32,00	87,77	36,35	95		
96	95,88	4,71	95,54	9,41	94,96	14,09	94,16	18,73	93,12	23,33	91,87	27,87	90,39	32,34	88,69	36,74	96		
97	96,88	4,76	96,53	9,51	95,95	14,2	95,14	18,92	94,09	23,57	92,82	28,16	91,33	32,68	89,62	37,12	97		
98	97,88	4,81	97,53	9,61	96,94	14,38	96,12	19,12	95,06	23,81	93,78	28,45	92,27	33,01	90,54	37,50	98		
99	98,88	4,86	98,52	9,70	97,93	14,53	97,10	19,3	96,03	24,05	94,74	28,74	93,21	33,35	91,46	37,88	99		
100	99,88	4,91	99,52	9,80	98,92	4,6	98,08	19,51	97,00	24,30	95,69	29,03	94,15	33,69	92,39	38,27	100		
101	100,9	4,96	100,5	9,90	99,91	14,82	99,06	19,70	97,97	24,54	96,65	29,32	95,10	34,03	93,31	38,65	101		
102	101,9	5,01	101,5	10,00	100,9	14,97	100,0	19,90	98,94	24,78	97,61	29,61	96,04	34,36	94,24	39,03	102		
103	102,9	5,05	102,5	10,10	101,9	15,11	101,0	20,09	99,91	25,03	98,56	29,90	96,98	34,70	95,16	39,42	103		
104	103,9	5,10	103,5	10,19	102,9	15,26	102,0	20,29	100,9	25,27	99,52	30,10	97,92	35,04	96,08	39,80	104		
105	104,9	5,15	104,5	10,29	103,9	15,41	103,0	20,48	101,9	25,51	100,5	30,48	98,86	35,37	97,01	40,18	1		

7 Points

6 Points

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Distance	2 Points						3 Points						4 Points						Distance
	$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0		$\frac{1}{4}$		$\frac{1}{2}$		$\frac{3}{4}$		0				
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.			
1	0,90	0,43	0,88	0,47	0,86	0,51	0,83	0,56	0,81	0,60	0,77	0,63	0,74	0,67	0,71	0,71			
2	1,81	0,85	1,76	0,94	1,71	1,03	1,66	1,11	1,61	1,19	1,55	1,27	1,48	1,34	1,41	1,41			
3	2,71	1,28	2,63	1,41	2,57	1,54	2,49	1,67	2,41	1,79	2,32	1,90	2,22	2,0	2,12	2,12			
4	3,62	1,71	3,53	1,89	3,43	2,06	3,33	2,22	3,21	2,38	3,9	2,54	2,96	2,09	2,83	2,83			
5	4,52	2,14	4,41	2,36	4,29	2,57	4,16	2,78	4,02	2,98	3,86	3,17	3,70	3,36	3,53	3,53			
6	5,42	2,56	5,29	2,83	5,15	3,08	4,99	3,33	4,82	3,57	4,64	3,81	4,45	4,03	4,24	4,24			
7	6,33	2,99	6,17	3,30	6,00	3,60	5,82	3,89	5,62	4,17	5,41	4,44	5,19	4,70	4,95	4,95			
8	7,23	3,42	7,05	3,77	6,86	4,11	6,65	4,44	6,45	4,77	6,18	5,07	5,93	5,37	5,66	5,66			
9	8,14	3,85	7,94	4,24	7,72	4,63	7,48	5,00	7,23	5,36	6,96	5,71	6,67	6,04	6,36	6,36			
10	9,04	4,28	8,83	4,71	8,58	5,14	8,32	5,56	8,03	5,96	7,73	6,34	7,41	6,72	7,07	7,07			
11	9,94	4,70	9,70	5,18	9,43	5,65	9,15	6,11	8,83	6,55	8,50	6,98	8,15	7,39	7,78	7,78			
12	10,8	5,13	10,58	5,66	10,29	6,17	9,98	6,67	9,64	7,15	9,28	7,61	8,89	8,06	8,49	8,49			
13	11,75	5,56	11,46	6,13	11,15	6,68	10,81	7,22	10,44	7,74	10,05	8,25	9,63	8,73	9,19	9,19			
14	12,66	5,99	12,35	6,60	12,01	7,20	11,64	7,78	11,24	8,33	10,82	8,88	10,37	9,40	9,90	9,90			
15	13,56	6,41	13,25	7,07	12,87	7,71	12,47	8,33	12,05	8,93	11,59	9,51	11,11	10,0	10,61	10,61			
16	14,46	6,84	14,11	7,54	13,70	8,22	13,30	8,89	12,85	9,52	12,37	10,15	11,8	10,75	11,31	11,31			
17	15,37	7,27	14,99	8,01	14,58	8,74	14,13	9,45	13,65	10,12	13,4	10,78	12,60	11,42	12,02	12,02			
18	16,27	7,70	15,87	8,48	15,44	9,25	14,96	10,00	14,46	10,71	13,91	11,42	13,34	12,09	12,73	12,73			
19	17,18	8,13	16,76	8,95	16,30	9,77	15,80	10,56	15,28	11,31	14,69	12,05	14,08	12,70	13,43	13,43			
20	18,08	8,56	17,64	9,43	17,15	10,28	16,63	11,12	16,06	11,91	15,46	12,69	14,82	13,43	14,14	14,14			
21	18,98	8,98	18,52	9,90	18,01	10,80	17,46	11,67	16,87	12,31	16,23	13,32	15,56	14,10	14,85	14,85			
22	19,89	9,41	19,4	10,37	18,87	11,31	18,29	12,23	17,67	13,11	17,01	13,95	16,30	14,77	15,56	15,56			
23	20,79	9,83	20,28	10,84	19,73	11,82	19,12	12,78	18,47	13,70	17,78	14,59	17,04	15,45	16,26	16,26			
24	21,69	10,26	21,17	11,31	20,59	12,34	19,95	13,34	19,28	14,30	18,55	15,22	17,78	16,12	16,97	16,97			
25	22,60	10,69	22,05	11,78	21,44	12,85	20,78	13,89	20,08	14,89	19,33	15,86	18,52	16,79	17,68	17,68			
26	23,50	11,12	22,93	12,25	22,30	13,37	21,62	14,45	20,88	15,49	20,10	16,49	19,26	17,46	18,38	18,38			
27	24,41	11,55	23,81	12,72	23,16	13,88	22,45	15,00	21,68	16,09	20,87	17,12	20,01	18,13	19,09	19,09			
28	25,31	11,97	24,69	13,2	24,02	14,39	23,28	15,56	22,49	16,68	21,64	17,76	20,75	18,81	19,80	19,80			
29	26,21	12,40	25,58	13,67	24,88	14,91	24,11	16,12	23,29	17,28	22,42	18,39	21,49	19,48	20,51	20,51			
30	27,12	12,83	26,46	14,14	25,73	15,42	24,94	16,67	24,10	17,87	23,19	19,03	22,23	20,15	21,21	21,21			
31	28,02	13,25	27,34	14,61	26,59	15,94	25,78	17,22	24,90	18,46	23,96	19,67	22,97	20,82	21,92	21,92			
32	28,93	13,68	28,23	15,09	27,45	16,45	26,61	17,78	25,70	19,06	24,74	20,30	23,71	21,49	22,63	22,63			
33	29,83	14,11	29,11	15,56	28,31	16,96	27,44	18,34	26,51	19,66	25,51	20,93	24,45	22,16	23,33	23,33			
34	30,73	14,54	29,99	16,03	29,16	17,48	28,27	18,89	27,31	20,25	26,28	21,57	25,19	22,83	24,04	24,04			
35	31,64	14,97	30,87	16,51	30,02	17,99	29,10	19,45	28,11	20,85	27,05	22,21	25,93	23,51	24,75	24,75			
36	32,54	15,39	31,76	16,98	30,88	18,51	29,93	20,00	28,91	21,45	27,83	22,84	26,67	24,8	25,46	25,46			
37	33,45	15,82	32,64	17,45	31,74	19,02	30,76	20,56	29,72	22,04	28,60	23,17	27,42	24,83	26,16	26,16			
38	34,35	16,25	33,52	17,92	32,60	19,53	31,59	21,12	30,52	22,64	29,37	24,10	28,16	25,52	26,87	26,87			
39	35,26	16,68	34,40	18,39	33,45	20,05	32,42	21,67	31,32	23,23	30,15	24,74	28,9	26,19	27,58	27,58			
40	36,16	17,10	35,28	18,86	34,31	20,56	33,26	22,22	32,13	23,83	30,92	25,38	29,64	26,86	28,28	28,28			
41	37,06	17,53	36,16	19,33	35,17	21,08	34,09	22,78	32,93	24,42	31,69	26,01	30,38	27,53	28,94	28,94			
42	37,97	17,96	37,04	19,80	36,03	21,59	34,92	23,34	33,73	25,02	32,47	26,64	31,12	28,21	29,70	29,70			
43	38,87	18,39	37,92	20,27	36,88	22,10	35,75	23,89	34,4	25,62	33,24	27,28	31,86	28,88	30,41	30,41			
44	39,77	18,81	38,80	20,74	37,74	22,61	36,58	24,45	35,34	26,21	34,01	27,91	32,60	29,55	31,11	31,11			
45	40,68	19,24	39,69	21,21	38,60	23,13	37,41	25,00	36,14	26,82	34,78	28,55	33,34	30,22	31,82	31,82			
46	41,58	19,67	40,57	21,68	39,46	23,65	38,24	25,56	36,95	27,41	35,56	29,18	34,08	30,89	32,53	32,53			
47	42,49	20,10	41,45	22,15	40,32	24,16	39,08	26,12	37,75	28,01	36,33	29,81	34,82	31,57	33,23	33,23			
48	43,39	20,53	42,33	22,62	41,17	24,68	39,91	26,67	38,55	28,61	37,10	30,45	35,57	32,24	33,94	33,94			
49	44,29	20,95	43,21	23,09	42,03	25,19	40,74	27,23	39,36	29,20	37,88	31,08	36,31	32,91	34,65	34,65			
50	45,20	21,38	44,10	23,57	42,89	25,70	41,57	27,78	40,16	29,79	38,65	31,72	37,05	33,58	35,35	35,35			
51	46,10	21,81	44,98	24,04	43,74	26,22	42,40	28,34	40,96	30,38	39,42	32,3	37,79	34,25	36,06	36,06			
52	47,01	22,23	45,86	24,51	44,60	26,73	43,23	28,89	41,77	30,98	40,20	32,99	38,53	34,92	36,77	36,77			
53	47,91	22,66	46,74	24,98	45,46	27,25	44,07	29,45	42,57	31,57	40,97	33,62	39,27	35,59	37,47	37,47			
54	48,81	23,09	47,62	25,4	46,32	27,76	44,90	30,00	43,37	32,17	41,74	34,26	40,01	36,27	38,18	38,18			
55	49,72	23,52	48,51	25,92	47,18	28,27	45,73	30,56	44,18	32,76	42,52	34,89	40,75	36,94	38,89	38,89			
56	50,62	23,95	49,39	26,40	48,03	28,79	46,56	31,12	44,98	33,36	43,29	35,52	41,49	37,61	39,60	39,60			
57	51,53	24,37	50,27	26,87	48,89	29,30	47,39	31,67	45,78	33,96	44,06	36,16	42,23	38,28	40,30	40,30			
58	52,43	24,80	51,15	27,34	49,75	29,82	48,22	32,23	46,58	34,55	44,83	36,79	42,98	38,95	41,01	41,01			
59	53,33	25,22	52,03	27,81	50,61	30,33	49,05	32,78	47,39	35,15	45,61	37,43	43,72	39,63	41,72	41,72			
60	54,24	25,6	52,92	28,28	51,46	30,85	49,89	33,33	48,19	35,74	46,38	38,06	44,46	40,29	42,43	42,43			
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance		
	$\frac{3}{4}$		$\frac{1}{2}$		$\frac{1}{4}$		0		$\frac{3}{4}$		$\frac{1}{2}$		$\frac{1}{4}$		0				
5 Points																	4 Points		

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Distance	0 Degrees						1 Degree												Distance	
	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.							
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.						
1	1,00	0,00	1,00	0,01	1,00	0,01	1,00	0,02	1,00	0,02	1,00	0,03	1,00	0,03	1					
2	2,00	0,01	2,00	0,02	2,00	0,03	2,00	0,04	2,00	0,04	2,00	0,05	2,00	0,06	2					
3	3,00	0,01	3,00	0,03	3,00	0,04	3,00	0,05	3,00	0,07	3,00	0,08	3,00	0,09	3					
4	4,00	0,02	4,00	0,03	4,00	0,05	4,00	0,07	4,00	0,09	4,00	0,10	4,00	0,12	4					
5	5,00	0,02	5,00	0,04	5,00	0,07	5,00	0,09	5,00	0,11	5,00	0,13	5,00	0,15	5					
6	6,00	0,03	6,00	0,05	6,00	0,08	6,00	0,11	6,00	0,13	6,00	0,16	6,00	0,18	6					
7	7,00	0,03	7,00	0,06	7,00	0,09	7,00	0,12	7,00	0,15	7,00	0,18	7,00	0,21	7					
8	8,00	0,04	8,00	0,07	8,00	0,10	8,00	0,14	8,00	0,18	8,00	0,21	8,00	0,25	8					
9	9,00	0,04	9,00	0,08	9,00	0,12	9,00	0,16	9,00	0,20	9,00	0,24	9,00	0,28	9					
10	10,00	0,04	10,00	0,09	10,00	0,13	10,00	0,18	10,00	0,22	10,00	0,26	10,00	0,31	10					
11	11,00	0,05	11,00	0,10	11,00	0,14	11,00	0,19	11,00	0,24	11,00	0,28	11,00	0,34	11					
12	12,00	0,05	12,00	0,10	12,00	0,16	12,00	0,21	12,00	0,26	12,00	0,31	11,99	0,37	12					
13	13,00	0,06	13,00	0,11	13,00	0,17	13,00	0,23	13,00	0,28	13,00	0,34	12,99	0,40	13					
14	14,00	0,06	14,00	0,12	14,00	0,18	14,00	0,25	14,00	0,31	14,00	0,37	13,99	0,43	14					
15	15,00	0,07	15,00	0,13	15,00	0,20	15,00	0,26	15,00	0,33	15,00	0,39	14,99	0,46	15					
16	16,00	0,07	16,00	0,14	16,00	0,21	16,00	0,28	16,00	0,35	16,00	0,42	15,99	0,49	16					
17	17,00	0,07	17,00	0,15	17,00	0,22	17,00	0,30	17,00	0,37	17,00	0,45	16,99	0,52	17					
18	18,00	0,08	18,00	0,16	18,00	0,24	18,00	0,32	18,00	0,39	17,99	0,47	17,99	0,55	18					
19	19,00	0,08	19,00	0,17	19,00	0,25	19,00	0,33	19,00	0,42	18,99	0,50	18,99	0,58	19					
20	20,00	0,09	20,00	0,17	20,00	0,26	20,00	0,35	20,00	0,44	19,99	0,52	19,99	0,61	20					
21	21,00	0,09	21,00	0,18	21,00	0,28	21,00	0,37	21,00	0,46	20,99	0,55	20,99	0,64	21					
22	22,00	0,10	22,00	0,19	22,00	0,29	22,00	0,38	22,00	0,48	21,99	0,58	21,99	0,67	22					
23	23,00	0,10	23,00	0,20	23,00	0,30	23,00	0,40	23,00	0,50	22,99	0,60	22,99	0,70	23					
24	24,00	0,10	24,00	0,21	24,00	0,31	24,00	0,42	24,00	0,52	23,99	0,63	23,99	0,73	24					
25	25,00	0,11	25,00	0,22	25,00	0,33	25,00	0,44	24,99	0,55	24,99	0,65	24,99	0,76	25					
26	26,00	0,11	26,00	0,23	26,00	0,34	26,00	0,45	25,99	0,57	25,99	0,68	25,99	0,79	26					
27	27,00	0,12	27,00	0,24	27,00	0,35	27,00	0,47	26,99	0,59	26,99	0,71	26,99	0,83	27					
28	28,00	0,12	28,00	0,24	28,00	0,37	28,00	0,49	27,99	0,61	27,99	0,73	27,99	0,86	28					
29	29,00	0,13	29,00	0,25	29,00	0,38	29,00	0,51	28,99	0,63	28,99	0,76	28,99	0,89	29					
30	30,00	0,13	30,00	0,26	30,00	0,39	30,00	0,52	29,99	0,65	29,99	0,79	29,99	0,92	30					
31	31,00	0,14	31,00	0,27	31,00	0,41	31,00	0,54	30,99	0,68	30,99	0,81	30,99	0,95	31					
32	32,00	0,14	32,00	0,28	32,00	0,42	32,00	0,56	31,99	0,70	31,99	0,84	31,99	0,98	32					
33	33,00	0,14	33,00	0,29	33,00	0,43	33,00	0,58	32,99	0,72	32,99	0,86	32,99	1,01	33					
34	34,00	0,15	34,00	0,30	34,00	0,44	33,99	0,59	33,99	0,74	33,99	0,89	33,99	1,04	34					
35	35,00	0,15	35,00	0,31	35,00	0,46	34,99	0,61	34,99	0,76	34,99	0,92	34,99	1,07	35					
36	36,00	0,16	36,00	0,31	36,00	0,47	35,99	0,63	35,99	0,79	35,99	0,94	35,99	1,10	36					
37	37,00	0,16	37,00	0,32	37,00	0,48	36,99	0,65	36,99	0,81	36,99	0,97	36,98	1,13	37					
38	38,00	0,17	38,00	0,33	38,00	0,50	37,99	0,66	37,99	0,83	37,99	0,99	37,98	1,16	38					
39	39,00	0,17	39,00	0,34	39,00	0,51	38,99	0,68	38,99	0,85	38,99	1,02	38,98	1,19	39					
40	40,00	0,17	40,00	0,35	40,00	0,52	39,99	0,70	39,99	0,87	39,99	1,05	39,98	1,22	40					
41	41,00	0,18	41,00	0,36	41,00	0,54	40,99	0,72	40,99	0,89	40,99	1,07	40,98	1,25	41					
42	42,00	0,18	42,00	0,37	42,00	0,55	41,99	0,73	41,99	0,92	41,99	1,10	41,98	1,28	42					
43	43,00	0,19	43,00	0,38	43,00	0,56	42,99	0,75	42,99	0,94	42,99	1,13	42,98	1,31	43					
44	44,00	0,19	44,00	0,38	44,00	0,58	43,99	0,77	43,99	0,96	43,99	1,15	43,98	1,34	44					
45	45,00	0,20	45,00	0,39	45,00	0,59	44,99	0,79	44,99	0,98	44,99	1,18	44,98	1,37	45					
46	46,00	0,20	46,00	0,40	46,00	0,60	45,99	0,80	45,99	1,00	45,99	1,20	45,98	1,40	46					
47	47,00	0,21	47,00	0,41	47,00	0,61	46,99	0,82	46,99	1,03	46,99	1,23	46,98	1,44	47					
48	48,00	0,21	48,00	0,42	48,00	0,63	47,99	0,84	47,99	1,05	47,98	1,26	47,98	1,47	48					
49	49,00	0,21	49,00	0,43	49,00	0,64	48,99	0,86	48,99	1,07	48,98	1,28	48,98	1,50	49					
50	50,00	0,22	50,00	0,44	50,00	0,65	49,99	0,87	49,99	1,09	49,98	1,31	49,98	1,53	50					
51	51,00	0,22	51,00	0,45	50,99	0,67	50,99	0,89	50,99	1,11	50,98	1,34	50,98	1,56	51					
52	52,00	0,23	52,00	0,45	51,99	0,68	51,99	0,91	51,99	1,14	51,98	1,36	51,98	1,59	52					
53	53,00	0,23	53,00	0,46	52,99	0,69	52,99	0,93	52,99	1,16	52,98	1,39	52,98	1,62	53					
54	54,00	0,24	54,00	0,47	53,99	0,71	53,99	0,94	53,99	1,18	53,98	1,41	53,98	1,65	54					
55	55,00	0,24	55,00	0,48	54,99	0,72	54,99	0,96	54,99	1,20	54,98	1,44	54,98	1,68	55					
56	56,00	0,24	56,00	0,49	55,99	0,73	55,99	0,98	55,99	1,22	55,98	1,47	55,98	1,71	56					
57	57,00	0,25	57,00	0,50	56,99	0,75	56,99	1,00	56,99	1,24	56,98	1,49	56,97	1,74	57					
58	58,00	0,25	58,00	0,51	57,99	0,76	57,99	1,01	57,99	1,27	57,98	1,52	57,97	1,77	58					
59	59,00	0,26	59,00	0,51	58,99	0,77	58,99	1,03	58,99	1,29	58,98	1,54	58,97	1,80	59					
60	60,00	0,26	60,00	0,52	59,99	0,79	59,99	1,05	59,99	1,31	59,98	1,57	59,97	1,83	60					
Distance	89 Degrees						88 Degrees												Distance	
	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.							
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.						

TRAVERSE TABLE, 712.

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Distance	0 Degrees						1 Degree								Distance
	15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	61,00	0,27	61,00	0,53	60,99	0,80	60,99	1,06	60,98	1,33	60,98	1,60	60,97	1,86	61
62	62,00	0,27	62,00	0,54	61,99	0,81	61,99	1,08	61,98	1,35	61,98	1,62	61,97	1,89	62
63	63,00	0,28	63,00	0,55	62,99	0,82	62,99	1,10	62,98	1,38	62,98	1,65	62,97	1,92	63
64	64,00	0,28	64,00	0,56	63,99	0,84	63,99	1,12	63,98	1,40	63,98	1,67	63,97	1,95	64
65	65,00	0,28	65,00	0,57	64,99	0,85	64,99	1,13	64,98	1,42	64,98	1,70	64,97	1,99	65
66	66,00	0,29	66,00	0,58	65,99	0,86	65,99	1,15	65,98	1,44	65,98	1,73	65,97	2,02	66
67	67,00	0,29	67,00	0,58	66,99	0,88	66,99	1,17	66,98	1,46	66,98	1,75	66,97	2,05	67
68	68,00	0,30	68,00	0,59	67,99	0,89	67,99	1,19	67,98	1,48	67,98	1,78	67,97	2,08	68
69	69,00	0,30	69,00	0,60	68,99	0,90	68,99	1,20	68,98	1,50	68,98	1,81	68,97	2,11	69
70	70,00	0,31	70,00	0,61	69,99	0,92	69,99	1,22	69,98	1,53	69,98	1,83	69,97	2,14	70
71	71,00	0,31	71,00	0,62	70,99	0,93	70,99	1,24	70,98	1,55	70,98	1,86	70,97	2,17	71
72	72,00	0,31	72,00	0,63	71,99	0,94	71,99	1,26	71,98	1,57	71,98	1,88	71,97	2,20	72
73	73,00	0,32	73,00	0,64	72,99	0,96	72,99	1,27	72,98	1,59	72,98	1,91	72,97	2,23	73
74	74,00	0,32	74,00	0,65	73,99	0,97	73,99	1,29	73,98	1,62	73,98	1,94	73,97	2,26	74
75	75,00	0,33	75,00	0,65	74,99	0,98	74,99	1,31	74,98	1,64	74,98	1,96	74,97	2,29	75
76	76,00	0,33	76,00	0,66	75,99	0,99	75,99	1,33	75,98	1,66	75,97	1,99	75,97	2,32	76
77	77,00	0,34	77,00	0,67	76,99	1,01	76,99	1,34	76,98	1,68	76,97	2,02	76,97	2,35	77
78	78,00	0,34	78,00	0,68	77,99	1,02	77,99	1,36	77,98	1,70	77,97	2,04	77,96	2,38	78
79	79,00	0,35	79,00	0,69	78,99	1,03	78,99	1,38	78,98	1,72	78,97	2,07	78,96	2,41	79
80	80,00	0,35	80,00	0,70	79,99	1,05	79,99	1,40	79,98	1,75	79,97	2,09	79,96	2,44	80
81	81,00	0,35	81,00	0,71	80,99	1,06	80,99	1,41	80,98	1,77	80,97	2,12	80,96	2,47	81
82	82,00	0,36	82,00	0,72	81,99	1,07	81,99	1,43	81,98	1,79	81,97	2,15	81,96	2,50	82
83	83,00	0,36	83,00	0,72	82,99	1,09	82,99	1,45	82,98	1,81	82,97	2,17	82,96	2,54	83
84	84,00	0,37	84,00	0,73	83,99	1,10	83,99	1,47	83,98	1,83	83,97	2,20	83,96	2,57	84
85	85,00	0,37	85,00	0,74	84,99	1,11	84,99	1,48	84,98	1,85	84,97	2,23	84,96	2,60	85
86	86,00	0,38	86,00	0,75	85,99	1,13	85,99	1,50	85,98	1,88	85,97	2,25	85,96	2,63	86
87	87,00	0,38	87,00	0,76	86,99	1,14	86,99	1,52	86,98	1,90	86,97	2,28	86,96	2,66	87
88	88,00	0,38	88,00	0,77	87,99	1,15	87,99	1,54	87,98	1,92	87,97	2,30	87,96	2,69	88
89	89,00	0,39	89,00	0,78	88,99	1,16	88,99	1,55	88,98	1,94	88,97	2,33	88,96	2,72	89
90	90,00	0,39	90,00	0,79	89,99	1,18	89,99	1,57	89,98	1,96	89,97	2,36	89,96	2,75	90
91	91,00	0,40	91,00	0,79	90,99	1,19	90,99	1,59	90,98	1,99	90,97	2,38	90,96	2,78	91
92	92,00	0,40	92,00	0,80	91,99	1,20	91,99	1,61	91,98	2,01	91,97	2,41	91,96	2,81	92
93	93,00	0,41	93,00	0,81	92,99	1,22	92,99	1,62	92,98	2,03	92,97	2,43	92,96	2,84	93
94	94,00	0,41	94,00	0,82	93,99	1,23	93,99	1,64	93,98	2,05	93,97	2,46	93,96	2,87	94
95	95,00	0,41	95,00	0,83	94,99	1,24	94,99	1,66	94,98	2,07	94,97	2,49	94,96	2,90	95
96	96,00	0,42	96,00	0,84	95,99	1,26	95,99	1,68	95,98	2,09	95,97	2,51	95,96	2,94	96
97	97,00	0,42	97,00	0,85	96,99	1,27	96,99	1,69	96,98	2,12	96,97	2,54	96,96	2,96	97
98	98,00	0,43	98,00	0,86	97,99	1,28	97,99	1,71	97,98	2,14	97,97	2,57	97,96	2,99	98
99	99,00	0,43	99,00	0,86	98,99	1,30	98,99	1,73	98,98	2,16	98,97	2,59	98,96	3,02	99
100	100,00	0,44	100,00	0,87	99,99	1,31	99,99	1,75	99,98	2,18	99,97	2,62	99,96	3,05	100
101	101,00	0,44	101,00	0,88	101,00	1,32	101,00	1,76	101,00	2,20	101,00	2,64	101,00	3,09	101
102	102,00	0,45	102,00	0,89	102,00	1,34	102,00	1,78	102,00	2,23	102,00	2,67	102,00	3,12	102
103	103,00	0,45	103,00	0,90	103,00	1,35	103,00	1,80	103,00	2,25	103,00	2,70	103,00	3,15	103
104	104,00	0,45	104,00	0,91	104,00	1,36	104,00	1,82	104,00	2,27	104,00	2,72	104,00	3,18	104
105	105,00	0,46	105,00	0,92	105,00	1,37	105,00	1,83	105,00	2,29	105,00	2,75	105,00	3,21	105
106	106,00	0,46	106,00	0,92	106,00	1,39	106,00	1,85	106,00	2,31	106,00	2,78	106,00	3,24	106
107	107,00	0,47	107,00	0,93	107,00	1,40	107,00	1,87	107,00	2,33	107,00	2,80	107,00	3,27	107
108	108,00	0,47	108,00	0,95	108,00	1,41	108,00	1,89	108,00	2,36	108,00	2,83	108,00	3,30	108
109	109,00	0,48	109,00	0,95	109,00	1,43	109,00	1,90	109,00	2,38	109,00	2,85	109,00	3,33	109
110	110,00	0,48	110,00	0,96	110,00	1,44	110,00	1,92	110,00	2,40	110,00	2,88	110,00	3,36	110
111	111,00	0,48	111,00	0,97	111,00	1,45	111,00	1,94	111,00	2,42	111,00	2,91	111,00	3,39	111
112	112,00	0,49	112,00	0,98	112,00	1,47	112,00	1,96	112,00	2,44	112,00	2,93	112,00	3,42	112
113	113,00	0,49	113,00	0,99	113,00	1,48	113,00	1,97	113,00	2,47	113,00	2,96	113,00	3,45	113
114	114,00	0,50	114,00	0,99	114,00	1,49	114,00	1,99	114,00	2,49	114,00	2,98	114,00	3,48	114
115	115,00	0,50	115,00	1,00	115,00	1,51	115,00	2,01	115,00	2,51	115,00	3,01	115,00	3,51	115
116	116,00	0,51	116,00	1,01	116,00	1,52	116,00	2,03	116,00	2,53	116,00	3,04	116,00	3,54	116
117	117,00	0,51	117,00	1,02	117,00	1,53	117,00	2,04	117,00	2,55	117,00	3,06	117,00	3,57	117
118	118,00	0,52	118,00	1,03	118,00	1,54	118,00	2,06	118,00	2,57	118,00	3,09	118,00	3,60	118
119	119,00	0,52	119,00	1,04	119,00	1,56	119,00	2,08	119,00	2,60	119,00	3,12	119,00	3,63	119
120	120,00	0,52	120,00	1,05	120,00	1,57	120,00	2,09	120,00	2,61	120,00	3,14	120,00	3,67	120
Distance	45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		Distance
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
	89 Degrees						88 Degrees								

Distance	2 Degrees								3 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	1,00	0,04	1,00	0,04	1,00	0,04	1,00	0,05	1,00	0,05	1,00	0,06	1,00	0,06	1,00	0,06	1
2	2,00	0,07	2,00	0,08	2,00	0,09	2,00	0,10	2,00	0,11	2,00	0,11	2,00	0,12	2,00	0,13	2
3	3,00	0,11	3,00	0,12	3,00	0,13	3,00	0,14	3,00	0,16	3,00	0,17	2,99	0,18	2,99	0,20	3
4	4,00	0,14	4,00	0,16	4,00	0,18	4,00	0,19	4,00	0,21	4,00	0,23	3,99	0,24	3,99	0,26	4
5	5,00	0,18	5,00	0,20	5,00	0,22	4,99	0,24	4,99	0,26	4,99	0,28	4,99	0,31	4,99	0,33	5
6	6,00	0,21	6,00	0,24	5,99	0,26	5,99	0,29	5,99	0,31	5,99	0,34	5,99	0,37	5,99	0,39	6
7	7,00	0,24	7,00	0,28	6,99	0,31	6,99	0,34	6,99	0,37	6,99	0,40	6,99	0,43	6,99	0,46	7
8	7,99	0,28	7,99	0,31	7,99	0,35	7,99	0,38	7,99	0,42	7,99	0,45	7,99	0,49	7,98	0,52	8
9	8,99	0,31	8,99	0,35	8,99	0,39	8,99	0,43	8,99	0,47	8,99	0,51	8,98	0,55	8,98	0,59	9
10	9,99	0,35	9,99	0,39	9,99	0,44	9,99	0,48	9,99	0,52	9,99	0,57	9,98	0,61	9,98	0,65	10
11	10,99	0,38	10,99	0,43	10,99	0,48	10,99	0,53	10,99	0,58	10,98	0,62	10,98	0,67	10,98	0,72	11
12	11,99	0,42	11,99	0,47	11,99	0,52	11,99	0,58	11,98	0,63	11,98	0,68	11,98	0,73	11,97	0,79	12
13	12,99	0,45	12,99	0,51	12,99	0,57	12,99	0,62	12,98	0,68	12,98	0,74	12,98	0,79	12,97	0,85	13
14	13,99	0,49	13,99	0,55	13,99	0,61	13,98	0,67	13,98	0,73	13,98	0,79	13,97	0,86	13,97	0,92	14
15	14,99	0,52	14,99	0,59	14,99	0,65	14,98	0,72	14,98	0,79	14,98	0,85	14,97	0,92	14,97	0,98	15
16	15,99	0,56	15,99	0,63	15,99	0,70	15,98	0,77	15,98	0,84	15,97	0,91	15,97	0,98	15,97	1,05	16
17	16,99	0,59	16,99	0,67	16,98	0,74	16,98	0,82	16,98	0,89	16,97	0,96	16,97	1,04	16,96	1,11	17
18	17,99	0,63	17,99	0,71	17,98	0,79	17,98	0,86	17,98	0,94	17,97	1,02	17,97	1,10	17,96	1,18	18
19	18,99	0,66	18,99	0,75	18,98	0,83	18,98	0,91	18,98	0,99	18,97	1,08	18,96	1,16	18,96	1,24	19
20	19,99	0,70	19,99	0,79	19,98	0,87	19,98	0,96	19,97	1,05	19,97	1,13	19,96	1,22	19,96	1,31	20
21	20,99	0,73	20,99	0,83	20,98	0,92	20,98	1,01	20,97	1,10	20,97	1,19	20,96	1,28	20,96	1,37	21
22	21,99	0,77	21,98	0,86	21,98	0,96	21,98	1,06	21,97	1,15	21,97	1,25	21,96	1,34	21,95	1,44	22
23	22,99	0,80	22,98	0,90	22,98	1,00	22,97	1,10	22,97	1,20	22,96	1,30	22,96	1,40	22,95	1,50	23
24	23,99	0,84	23,98	0,94	23,98	1,05	23,97	1,15	23,97	1,26	23,96	1,36	23,96	1,47	23,95	1,57	24
25	24,99	0,87	24,98	0,98	24,98	1,09	24,97	1,20	24,97	1,31	24,96	1,42	24,95	1,53	24,95	1,64	25
26	25,98	0,91	25,98	1,02	25,98	1,12	25,97	1,25	25,97	1,36	25,96	1,47	25,95	1,59	25,94	1,70	26
27	26,98	0,94	26,98	1,06	26,97	1,18	26,97	1,30	26,96	1,41	26,96	1,53	26,95	1,65	26,94	1,77	27
28	27,98	0,98	27,98	1,10	27,97	1,22	27,97	1,34	27,96	1,47	27,96	1,59	27,95	1,71	27,94	1,83	28
29	28,98	1,01	28,98	1,14	28,97	1,27	28,97	1,39	28,96	1,52	28,95	1,64	28,95	1,77	28,94	1,90	29
30	29,98	1,05	29,98	1,18	29,97	1,31	29,97	1,44	29,96	1,57	29,95	1,70	29,94	1,83	29,94	1,96	30
31	30,98	1,08	30,98	1,22	30,97	1,35	30,97	1,49	30,96	1,62	30,95	1,76	30,94	1,89	30,93	2,03	31
32	31,98	1,12	31,98	1,26	31,97	1,40	31,96	1,54	31,96	1,68	31,95	1,81	31,94	1,95	31,93	2,09	32
33	32,98	1,15	32,98	1,30	32,97	1,44	32,96	1,58	32,96	1,73	32,95	1,87	32,94	2,01	32,93	2,16	33
34	33,98	1,19	33,97	1,34	33,97	1,48	33,96	1,63	33,96	1,78	33,95	1,93	33,94	2,08	33,93	2,22	34
35	34,98	1,22	34,97	1,37	34,97	1,53	34,96	1,68	34,95	1,83	34,94	1,99	34,94	2,14	34,92	2,29	35
36	35,98	1,26	35,97	1,41	35,97	1,57	35,96	1,73	35,95	1,88	35,94	2,04	35,93	2,20	35,92	2,35	36
37	36,98	1,29	36,97	1,45	36,97	1,61	36,96	1,78	36,95	1,94	36,94	2,10	36,93	2,26	36,92	2,42	37
38	37,98	1,33	37,97	1,49	37,96	1,66	37,96	1,82	37,95	1,99	37,94	2,16	37,93	2,32	37,92	2,49	38
39	38,98	1,36	38,97	1,53	38,96	1,70	38,96	1,87	38,95	2,04	38,94	2,21	38,93	2,38	38,92	2,55	39
40	39,98	1,40	39,97	1,57	39,96	1,75	39,95	1,92	39,95	2,09	39,94	2,27	39,93	2,44	39,91	2,62	40
41	40,98	1,43	40,97	1,61	40,96	1,79	40,95	1,97	40,94	2,15	40,93	2,33	40,92	2,50	40,91	2,68	41
42	41,97	1,47	41,97	1,65	41,96	1,83	41,95	2,02	41,94	2,20	41,93	2,38	41,92	2,56	41,91	2,75	42
43	42,97	1,50	42,97	1,69	42,96	1,88	42,95	2,06	42,94	2,25	42,93	2,44	42,92	2,63	42,91	2,81	43
44	43,97	1,54	43,97	1,73	43,96	1,92	43,95	2,11	43,94	2,30	43,93	2,50	43,92	2,69	43,91	2,88	44
45	44,97	1,57	44,97	1,77	44,96	1,96	44,95	2,16	44,94	2,36	44,93	2,55	44,92	2,75	44,90	2,94	45
46	45,97	1,61	45,97	1,81	45,96	2,01	45,95	2,21	45,94	2,41	45,93	2,61	45,91	2,81	45,90	3,00	46
47	46,97	1,64	46,97	1,85	46,96	2,05	46,95	2,26	46,94	2,47	46,93	2,67	46,91	2,87	46,90	3,07	47
48	47,97	1,68	47,96	1,88	47,95	2,09	47,95	2,30	47,94	2,51	47,92	2,72	47,91	2,93	47,90	3,14	48
49	48,97	1,71	48,96	1,92	48,95	2,14	48,94	2,35	48,93	2,57	48,92	2,78	48,91	2,99	48,90	3,21	49
50	49,97	1,75	49,96	1,96	49,95	2,18	49,94	2,40	49,93	2,62	49,92	2,84	49,91	3,05	49,89	3,27	50
51	50,97	1,78	50,96	2,00	50,95	2,23	50,94	2,45	50,93	2,67	50,92	2,89	50,90	3,11	50,89	3,34	51
52	51,97	1,82	51,96	2,04	51,95	2,27	51,94	2,50	51,93	2,72	51,92	2,95	51,90	3,18	51,89	3,40	52
53	52,97	1,85	52,96	2,08	52,95	2,31	52,94	2,54	52,93	2,77	52,92	3,01	52,90	3,24	52,89	3,47	53
54	53,97	1,89	53,96	2,12	53,95	2,36	53,94	2,59	53,93	2,83	53,91	3,06	53,90	3,30	53,88	3,53	54
55	54,97	1,92	54,96	2,16	54,95	2,40	54,94	2,64	54,92	2,88	54,91	3,12	54,90	3,36	54,88	3,60	55
56	55,97	1,95	55,96	2,20	55,95	2,44	55,94	2,69	55,92	2,93	55,91	3,18	55,90	3,42	55,88	3,66	56
57	56,97	1,99	56,96	2,24	56,95	2,49	56,93	2,74	56,92	2,98	56,91	3,23	56,89	3,48	56,88	3,73	57
58	57,97	2,02	57,96	2,28	57,95	2,53	57,93	2,78	57,92	3,04	57,91	3,29	57,89	3,54	57,88	3,79	58
59	58,96	2,06	58,96	2,32	58,94	2,57	58,93	2,83	58,92	3,09	58,91	3,35	58,89	3,60	58,87	3,85	59
60	59,96	2,09	59,95	2,36	59,94	2,62	59,93	2,88	59,92	3,14	59,90	3,40	59,89	3,66	59,87	3,92	60
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		88 Degrees
																	87 Degrees
																	86 Degrees

TRAVERSE TABLE, 712.

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Distance	2 Degrees								3 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,96	2,13	60,95	2,40	60,94	2,66	60,93	2,93	60,92	3,19	60,90	3,46	60,89	3,72	60,87	3,99	61
62	61,96	2,16	61,95	2,43	61,94	2,70	61,93	2,98	61,92	3,25	61,90	3,51	61,88	3,79	61,87	4,06	62
63	62,96	2,20	62,95	2,47	62,94	2,75	62,93	3,02	62,92	3,30	62,90	3,57	62,88	3,85	62,87	4,12	63
64	63,96	2,23	63,95	2,51	63,94	2,79	63,93	3,07	63,91	3,35	63,90	3,63	63,88	3,91	63,86	4,19	64
65	64,96	2,27	64,95	2,55	64,94	2,84	64,93	3,12	64,91	3,40	64,90	3,69	64,88	3,97	64,86	4,25	65
66	65,96	2,30	65,95	2,59	65,94	2,88	65,92	3,17	65,91	3,46	65,89	3,74	65,88	4,03	65,86	4,32	66
67	66,96	2,34	66,95	2,63	66,94	2,92	66,92	3,22	66,91	3,51	66,89	3,80	66,88	4,09	66,86	4,38	67
68	67,96	2,37	67,95	2,67	67,94	2,97	67,92	3,26	67,91	3,56	67,89	3,86	67,87	4,16	67,86	4,45	68
69	68,96	2,40	68,95	2,71	68,94	3,01	68,92	3,31	68,91	3,61	68,89	3,91	68,87	4,22	68,85	4,51	69
70	69,96	2,44	69,95	2,75	69,93	3,05	69,92	3,36	69,91	3,66	69,89	3,97	69,87	4,28	69,85	4,58	70
71	70,96	2,48	70,95	2,79	70,93	3,10	70,92	3,41	70,90	3,72	70,89	4,03	70,87	4,34	70,85	4,64	71
72	71,96	2,51	71,95	2,83	71,93	3,14	71,92	3,46	71,90	3,77	71,88	4,08	71,87	4,40	71,85	4,71	72
73	72,96	2,55	72,94	2,87	72,93	3,18	72,92	3,50	72,90	3,82	72,88	4,14	72,86	4,46	72,84	4,77	73
74	73,96	2,58	73,94	2,91	73,93	3,23	73,92	3,55	73,90	3,87	73,88	4,20	73,86	4,52	73,84	4,84	74
75	74,96	2,61	74,94	2,94	74,93	3,27	74,92	3,60	74,90	3,93	74,88	4,25	74,86	4,58	74,84	4,91	75
76	75,96	2,65	75,94	2,98	75,93	3,31	75,91	3,65	75,90	3,98	75,88	4,31	75,86	4,64	75,84	4,97	76
77	76,96	2,69	76,94	3,02	76,93	3,36	76,91	3,70	76,90	4,03	76,88	4,37	76,86	4,70	76,84	5,04	77
78	77,96	2,73	77,94	3,06	77,93	3,40	77,91	3,74	77,89	4,08	77,87	4,42	77,85	4,76	77,83	5,10	78
79	78,95	2,76	78,94	3,10	78,93	3,45	78,91	3,79	78,89	4,14	78,87	4,48	78,85	4,82	78,83	5,17	79
80	79,95	2,79	79,94	3,14	79,93	3,49	79,91	3,84	79,89	4,19	79,87	4,54	79,85	4,88	79,83	5,23	80
81	80,95	2,83	80,94	3,18	80,92	3,53	80,91	3,89	80,89	4,24	80,87	4,59	80,85	4,95	80,83	5,30	81
82	81,95	2,86	81,94	3,22	81,92	3,58	81,91	3,94	81,89	4,29	81,87	4,65	81,85	5,01	81,83	5,36	82
83	82,95	2,90	82,94	3,26	82,92	3,62	82,91	3,98	82,89	4,34	82,87	4,71	82,84	5,07	82,82	5,43	83
84	83,95	2,93	83,94	3,30	83,92	3,66	83,91	4,03	83,89	4,40	83,87	4,76	83,84	5,13	83,82	5,49	84
85	84,95	2,97	84,94	3,34	84,92	3,71	84,90	4,08	84,88	4,45	84,86	4,82	84,84	5,19	84,82	5,56	85
86	85,95	3,00	85,93	3,38	85,92	3,75	85,90	4,13	85,88	4,50	85,86	4,88	85,84	5,25	85,82	5,62	86
87	86,95	3,04	86,93	3,42	86,92	3,79	86,90	4,18	86,88	4,55	86,86	4,93	86,84	5,31	86,81	5,69	87
88	87,95	3,07	87,93	3,46	87,92	3,84	87,90	4,22	87,88	4,61	87,86	4,99	87,84	5,37	87,81	5,76	88
89	88,95	3,11	88,93	3,49	88,92	3,88	88,90	4,27	88,88	4,66	88,86	5,05	88,83	5,43	88,81	5,82	89
90	89,95	3,14	89,93	3,53	89,92	3,93	89,90	4,32	89,88	4,71	89,86	5,10	89,83	5,50	89,81	5,89	90
91	90,95	3,18	90,93	3,57	90,91	3,97	90,90	4,37	90,88	4,76	90,85	5,17	90,83	5,56	90,81	5,95	91
92	91,94	3,21	91,93	3,61	91,91	4,01	91,90	4,41	91,87	4,82	91,85	5,22	91,83	5,62	91,80	6,02	92
93	92,94	3,25	92,93	3,65	92,91	4,05	92,89	4,46	92,87	4,87	92,85	5,27	92,83	5,68	92,80	6,08	93
94	93,94	3,28	93,93	3,69	93,91	4,10	93,89	4,51	93,87	4,92	93,85	5,33	93,83	5,74	93,80	6,15	94
95	94,94	3,32	94,93	3,73	94,91	4,14	94,89	4,56	94,87	4,97	94,85	5,39	94,82	5,80	94,80	6,21	95
96	95,94	3,35	95,93	3,77	95,91	4,19	95,89	4,61	95,87	5,03	95,85	5,44	95,82	5,86	95,79	6,28	96
97	96,94	3,39	96,93	3,81	96,91	4,23	96,89	4,65	96,87	5,08	96,84	5,50	96,82	5,92	96,79	6,34	97
98	97,94	3,42	97,93	3,85	97,91	4,28	97,89	4,70	97,87	5,13	97,84	5,55	97,82	5,98	97,79	6,41	98
99	98,94	3,46	98,92	3,89	98,91	4,32	98,89	4,75	98,87	5,18	98,84	5,61	98,82	6,04	98,79	6,48	99
100	99,94	3,49	99,92	3,93	99,91	4,36	99,89	4,80	99,86	5,23	99,84	5,67	99,81	6,11	99,79	6,54	100
101	100,9	3,53	100,9	3,97	100,9	4,41	100,9	4,85	100,9	5,29	100,8	5,73	100,8	6,17	100,8	6,61	101
102	101,9	3,56	101,9	4,01	101,9	4,45	101,9	4,89	101,9	5,34	101,8	5,78	101,8	6,23	101,8	6,67	102
103	102,9	3,60	102,9	4,04	102,9	4,49	102,9	4,94	102,9	5,39	102,8	5,84	102,8	6,29	102,8	6,74	103
104	103,9	3,63	103,9	4,08	103,9	4,54	103,9	4,99	103,9	5,44	103,8	5,90	103,8	6,35	103,8	6,80	104
105	104,9	3,67	104,9	4,12	104,9	4,58	104,9	5,04	104,9	5,50	104,8	5,95	104,8	6,41	104,8	6,87	105
106	105,9	3,70	105,9	4,16	105,9	4,62	105,9	5,09	105,9	5,55	105,8	6,01	105,8	6,47	105,8	6,93	106
107	106,9	3,73	106,9	4,20	106,9	4,67	106,9	5,13	106,9	5,60	106,8	6,07	106,8	6,53	106,8	7,00	107
108	107,9	3,77	107,9	4,24	107,9	4,71	107,9	5,18	107,9	5,65	107,8	6,12	107,8	6,59	107,8	7,06	108
109	108,9	3,80	108,9	4,28	108,9	4,76	108,9	5,23	108,9	5,71	108,8	6,18	108,8	6,66	108,8	7,13	109
110	109,9	3,84	109,9	4,32	109,9	4,80	109,9	5,28	109,9	5,76	109,8	6,24	109,8	6,72	109,8	7,19	110
111	110,9	3,87	110,9	4,36	110,9	4,84	110,9	5,33	110,8	5,81	110,8	6,29	110,8	6,78	110,8	7,26	111
112	111,9	3,91	111,9	4,40	111,9	4,89	111,9	5,37	111,8	5,86	111,8	6,35	111,8	6,84	111,8	7,33	112
113	112,9	3,94	112,9	4,44	112,9	4,93	112,9	5,42	112,8	5,92	112,8	6,41	112,8	6,90	112,8	7,3	

4 Degrees																	5 Degrees																
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.											
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.										
1	1,00	0,07	1,00	0,07	1,00	0,07	1,00	0,08	1,00	0,09	1,00	0,09	1,00	0,10	1,00	0,10	1	1,00	0,09	1,00	0,09	1,00	0,10	1,00	0,10								
2	2,00	0,14	2,00	0,15	1,99	0,16	1,99	0,17	1,99	0,17	1,99	0,18	1,99	0,19	1,99	0,20	2	2,00	0,14	2,00	0,15	1,99	0,16	1,99	0,17								
3	2,99	0,21	2,99	0,22	2,99	0,24	2,99	0,25	2,99	0,26	2,99	0,28	2,99	0,29	2,99	0,30	3	2,99	0,21	2,99	0,22	2,99	0,24	2,99	0,25								
4	3,99	0,28	3,99	0,30	3,99	0,31	3,99	0,33	3,99	0,35	3,98	0,37	3,98	0,38	3,98	0,40	4	3,99	0,28	3,99	0,30	3,99	0,31	3,99	0,33								
5	4,99	0,35	4,99	0,37	4,99	0,39	4,98	0,41	4,98	0,44	4,98	0,46	4,98	0,48	4,98	0,50	5	4,99	0,35	4,99	0,37	4,99	0,39	4,98	0,41								
6	5,99	0,42	5,98	0,45	5,98	0,47	5,98	0,49	5,98	0,52	5,98	0,55	5,97	0,58	5,97	0,60	6	5,99	0,42	5,98	0,45	5,98	0,47	5,98	0,49								
7	6,98	0,49	6,98	0,52	6,98	0,55	6,98	0,58	6,97	0,61	6,97	0,64	6,97	0,67	6,97	0,70	7	6,98	0,49	6,98	0,52	6,98	0,55	6,98	0,58								
8	7,98	0,56	7,98	0,59	7,98	0,63	7,97	0,66	7,97	0,70	7,97	0,73	7,96	0,78	7,96	0,80	8	7,98	0,56	7,98	0,59	7,98	0,63	7,97	0,66								
9	8,98	0,63	8,98	0,67	8,97	0,71	8,97	0,75	8,97	0,78	8,96	0,82	8,96	0,86	8,96	0,90	9	8,98	0,63	8,98	0,67	8,97	0,71	8,97	0,75								
10	9,98	0,70	9,97	0,74	9,97	0,79	9,97	0,83	9,96	0,87	9,96	0,92	9,95	0,96	9,95	1,00	10	9,98	0,70	9,97	0,74	9,97	0,79	9,97	0,83								
11	10,97	0,77	10,97	0,82	10,97	0,86	10,96	0,91	10,96	0,96	10,95	1,01	10,95	1,05	10,95	1,10	11	10,97	0,77	10,97	0,82	10,97	0,86	10,96	0,91								
12	11,97	0,84	11,97	0,89	11,96	0,94	11,96	0,99	11,95	1,05	11,95	1,10	11,95	1,15	11,94	1,20	12	11,97	0,84	11,97	0,89	11,96	0,94	11,96	0,99								
13	12,97	0,91	12,97	0,96	12,96	1,01	12,96	1,08	12,95	1,13	12,95	1,19	12,94	1,25	12,94	1,30	13	12,97	0,91	12,97	0,96	12,96	1,01	12,96	1,08								
14	13,97	0,98	13,96	1,04	13,96	1,10	13,95	1,16	13,95	1,22	13,94	1,28	13,94	1,34	13,93	1,40	14	13,97	0,98	13,96	1,04	13,96	1,10	13,95	1,16								
15	14,96	1,05	14,96	1,11	14,95	1,18	14,95	1,24	14,94	1,31	14,94	1,37	14,93	1,44	14,93	1,50	15	14,96	1,05	14,96	1,11	14,95	1,18	14,95	1,24								
16	15,96	1,12	15,96	1,19	15,95	1,26	15,95	1,33	15,94	1,40	15,93	1,46	15,93	1,53	15,92	1,60	16	15,96	1,12	15,96	1,19	15,95	1,26	15,95	1,33								
17	16,96	1,19	16,95	1,26	16,95	1,33	16,94	1,41	16,94	1,48	16,93	1,56	16,92	1,63	16,92	1,70	17	16,96	1,19	16,95	1,26	16,95	1,33	16,94	1,41								
18	17,96	1,26	17,95	1,33	17,94	1,41	17,94	1,49	17,93	1,57	17,92	1,65	17,92	1,73	17,91	1,80	18	17,96	1,26	17,95	1,33	17,94	1,41	17,94	1,49								
19	18,95	1,33	18,95	1,40	18,94	1,49	18,93	1,57	18,93	1,66	18,92	1,74	18,91	1,82	18,91	1,90	19	18,95	1,33	18,95	1,40	18,94	1,49	18,93	1,57								
20	19,95	1,40	19,95	1,48	19,94	1,57	19,93	1,66	19,92	1,74	19,91	1,83	19,91	1,92	19,90	2,00	20	19,95	1,40	19,95	1,48	19,94	1,57	19,93	1,66								
21	20,95	1,47	20,94	1,56	20,94	1,65	20,93	1,74	20,92	1,83	20,91	1,92	20,90	2,01	20,89	2,10	21	20,95	1,47	20,94	1,56	20,94	1,65	20,93	1,74								
22	21,95	1,54	21,94	1,63	21,93	1,73	21,93	1,82	21,92	1,92	21,91	2,01	21,90	2,11	21,89	2,20	22	21,95	1,54	21,94	1,63	21,93	1,73	21,93	1,82								
23	22,94	1,60	22,94	1,70	22,93	1,80	22,92	1,90	22,91	2,00	22,90	2,11	22,89	2,21	22,88	2,30	23	22,94	1,60	22,94	1,70	22,93	1,80	22,92	1,90								
24	23,94	1,67	23,93	1,78	23,93	1,88	23,92	1,99	23,91	2,09	23,90	2,20	23,89	2,30	23,88	2,40	24	23,94	1,67	23,93	1,78	23,93	1,88	23,92	1,99								
25	24,94	1,74	24,93	1,85	24,92	1,96	24,91	2,07	24,91	2,18	24,90	2,29	24,89	2,40	24,87	2,50	25	24,94	1,74	24,93	1,85	24,92	1,96	24,91	2,07								
26	25,94	1,81	25,93	1,93	25,92	2,04	25,91	2,15	25,90	2,27	25,89	2,38	25,88	2,49	25,87	2,60	26	25,94	1,81	25,93	1,93	25,92	2,04	25,91	2,15								
27	26,93	1,88	26,93	2,00	26,92	2,12	26,91	2,24	26,90	2,35	26,89	2,47	26,88	2,59	26,86	2,70	27	26,93	1,88	26,93	2,00	26,92	2,12	26,91	2,24								
28	27,93	1,95	27,92	2,08	27,91	2,20	27,90	2,32	27,89	2,44	27,88	2,56	27,87	2,68	27,86	2,80	28	27,93	1,95	27,92	2,08	27,91	2,20	27,90	2,32								
29	28,93	2,01	28,92	2,15	28,91	2,28	28,90	2,40	28,89	2,53	28,88	2,65	28,87	2,78	28,85	2,90	29	28,93	2,01	28,92	2,15	28,91	2,28	28,90	2,40								
30	29,93	2,09	29,92	2,22	29,91	2,35	29,90	2,48	29,89	2,62	29,87	2,75	29,86	2,88	29,85	3,00	30	29,93	2,09	29,92	2,22	29,91	2,35	29,90	2,48								
31	30,93	2,16	30,92	2,30	30,91	2,43	30,89	2,57	30,88	2,70	30,87	2,84	30,86	2,97	30,84	3,10	31	30,93	2,16	30,92	2,30	30,91	2,43	30,89	2,57								
32	31,92	2,23	31,91	2,37	31,90	2,51	31,89	2,65	31,88	2,79	31,87	2,93	31,85	3,07	31,84	3,20	32	31,92	2,23	31,91	2,37	31,90	2,51	31,89	2,65								
33	32,92	2,30	32,91	2,45	32,90	2,59	32,89	2,73	32,88	2,88	32,86	3,02	32,85	3,17	32,83	3,30	33	32,92	2,30	32,91	2,45	32,90	2,59	32,89	2,73								
34	33,92	2,37	33,91	2,52	33,90	2,67	33,88	2,82	33,87	2,96	33,86	3,11	33,85	3,26	33,83	3,40	34	33,92	2,37	33,91	2,52	33,90	2,67	33,88	2,82								
35	34,92	2,44	34,90	2,59	34,89	2,75	34,88	2,90	34,87	3,05	34,85	3,20	34,84	3,36	34,82	3,50	35	34,92	2,44	34,90	2,59	34,89	2,75	34,88	2,90								
36	35,91	2,51	35,90	2,67	35,89	2,83	35,88	2,98	35,86	3,14	35,85	3,29	35,84	3,45	35,82	3,60	36	35,91	2,51	35,90	2,67	35,89	2,83	35,88	2,98								
37	36,91	2,58	36,90	2,74	36,89	2,90	36,87	3,06	36,86	3,23	36,85	3,39	36,83	3,55	36,81	3,70	37	36,91	2,58	36,90	2,74	36,89	2,90	36,87	3,06								
38	37,91	2,65	37,90	2,82	37,88	2,98	37,87	3,15	37,86	3,31	37,84	3,48	37,83	3,64	37,81	3,80	38	37,91	2,65	37,90	2,82	37,88	2,98	37,87	3,15								
39	38,91	2,72	38,89	2,89	38,88	3,06	38,87	3,23	38,85	3,40	38,84	3,57	38,82	3,74	38,80	3,90	39	38,91	2,72	38,89	2,89	38,88	3,06	38,87	3,23								
40	39,90	2,79	39,89	2,96	39,88	3,14	39,86	3,31	39,85	3,49	39,83	3,66	39,82	3,83	39,80	4,00	40	39,90	2,79	39,89	2,96	39,88	3,14	39,86	3,31								
41	40,90	2,86	40,89	3,04	40,87	3,22	40,86	3,40	40,84	3,57	40,83	3,75	40,81	3,93	40,79	4,10	41	40,90	2,86	40,89	3,04	40,87	3,22	40,86	3,40								
42	41,90	2,93	41,89	3,11	41,87	3,30	41,86	3,48	41,84	3,66	41,82	3,84	41,81	4,03	41,79	4,20	42	41,90	2,93	41,89	3,11	41,87	3,30	41,86	3,48								
43	42,90	3,00	42,88	3,19	42,87	3,37	42,85	3,56	42,84	3,75	42,82	3,94	42,80	4,12	42,78	4,30	43	42,90	3,00	42,88	3,19	42,87	3,37	42,85	3,56								
44	43,89	3,07	43,88	3,26	43,87	3,45	43,85	3,64	43,83	3,84	43,82	4,03	43,80	4,22	43,78	4,40	44	43,89	3,07	43,88	3,26	43,87	3,45	43,85	3,64								
45	44,89	3,14	44,88	3,34	44,86	3,53	44,85	3,73	44,83	3,92	44,81	4,12	44,79	4,31	44,77	4,50	45	44,89	3,14	44,88	3,34	44,86	3,53	44,85	3,73								
46	45,89	3,21	45,87	3,41	45,86	3,61	45,84	3,81	45,83	4,00	45,81	4,21	45,79	4,41	45,77	4,60	46	45,89	3,21	45,87	3,41	45,86	3,61	45,84	3,81								
47	46,89	3,28	46,87	3,48	46,86	3,69	46,84	3,89	46,82	4,10	46,80	4,30	46,78	4,51	46,76	4,70	47	46,89	3,28	46,87	3,48	46,86	3,69	46,84	3,89								
48	47,88	3,35	47,87	3,56	47,85	3,77	47,84	3,97	47,82	4,18	47,80	4,39	47,78	4,60	47,76	4,80	48	47,88	3,35	47,87	3,56	47,85	3,77	47,84	3,97								
49	48,88	3,42	48,87	3,63	48,85	3,84	48,83	4,06	48,81	4,27	48,79	4,48	48,78	4,70	48,75	4,90	49	48,88	3,42	48,87	3,63	48,85	3,84	48,83	4,06								
50	49,88	3,49	49,86	3,71	49,85	3,92	49,83	4,14	49,81	4,36	49,79	4,58	49,77	4,79	49,75	5,00</																	

TRAVERSE TABLE, 712.

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Distance	4 Degrees								5 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,85	4,26	60,83	4,52	60,81	4,79	60,79	5,05	60,77	5,32	60,74	5,58	60,72	5,85	60,69	6,11	61
62	61,85	4,33	61,83	4,60	61,81	4,87	61,79	5,14	61,76	5,40	61,74	5,67	61,72	5,94	61,69	6,21	62
63	62,85	4,40	62,83	4,67	62,81	4,94	62,78	5,22	62,76	5,49	62,74	5,77	62,71	6,04	62,68	6,31	63
64	63,84	4,47	63,82	4,74	63,80	5,02	63,78	5,30	63,76	5,58	63,73	5,86	63,71	6,13	63,68	6,41	64
65	64,84	4,54	64,82	4,81	64,80	5,10	64,78	5,38	64,75	5,67	64,73	5,95	64,70	6,23	64,67	6,51	65
66	65,84	4,61	65,82	4,89	65,80	5,18	65,77	5,47	65,75	5,75	65,72	6,04	65,70	6,33	65,67	6,61	66
67	66,84	4,67	66,82	4,97	66,79	5,26	66,77	5,55	66,74	5,84	66,72	6,13	66,69	6,42	66,66	6,71	67
68	67,83	4,74	67,81	5,04	67,79	5,34	67,77	5,63	67,74	5,93	67,71	6,22	67,69	6,52	67,66	6,81	68
69	68,83	4,81	68,81	5,11	68,79	5,41	68,76	5,71	68,74	6,02	68,71	6,31	68,68	6,61	68,65	6,91	69
70	69,83	4,88	69,81	5,19	69,78	5,49	69,76	5,80	69,73	6,10	69,71	6,41	69,68	6,71	69,65	7,01	70
71	70,83	4,95	70,81	5,26	70,78	5,57	70,76	5,88	70,73	6,19	70,70	6,50	70,67	6,81	70,64	7,11	71
72	71,82	5,02	71,80	5,34	71,78	5,65	71,75	5,96	71,73	6,28	71,70	6,59	71,67	6,90	71,64	7,21	72
73	72,82	5,09	72,80	5,41	72,78	5,73	72,75	6,04	72,72	6,36	72,69	6,68	72,66	7,00	72,63	7,31	73
74	73,82	5,16	73,80	5,48	73,77	5,81	73,75	6,13	73,72	6,45	73,69	6,77	73,66	7,09	73,63	7,41	74
75	74,82	5,23	74,79	5,56	74,77	5,88	74,74	6,21	74,71	6,54	74,69	6,86	74,66	7,19	74,62	7,51	75
76	75,81	5,30	75,79	5,63	75,77	5,96	75,74	6,29	75,71	6,62	75,68	6,95	75,65	7,29	75,61	7,61	76
77	76,81	5,37	76,79	5,71	76,76	6,04	76,74	6,38	76,71	6,71	76,68	7,05	76,65	7,38	76,61	7,71	77
78	77,81	5,44	77,76	5,78	77,76	6,12	77,73	6,46	77,70	6,80	77,67	7,14	77,64	7,48	77,61	7,81	78
79	78,81	5,51	78,78	5,86	78,76	6,20	78,73	6,54	78,70	6,89	78,67	7,23	78,64	7,57	78,60	7,91	79
80	79,81	5,58	79,78	5,93	79,75	6,28	79,73	6,63	79,70	6,97	79,66	7,32	79,63	7,66	79,60	8,01	80
81	80,80	5,65	80,78	6,00	80,75	6,36	80,72	6,71	80,69	7,06	80,66	7,41	80,63	7,76	80,59	8,11	81
82	81,80	5,72	81,78	6,08	81,75	6,43	81,72	6,79	81,69	7,15	81,66	7,50	81,62	7,86	81,59	8,21	82
83	82,80	5,79	82,77	6,15	82,75	6,51	82,72	6,87	82,68	7,24	82,65	7,60	82,62	7,96	82,58	8,31	83
84	83,80	5,86	83,77	6,23	83,74	6,59	83,71	6,96	83,68	7,32	83,65	7,69	83,61	8,05	83,58	8,41	84
85	84,79	5,93	84,77	6,30	84,74	6,67	84,71	7,04	84,68	7,41	84,64	7,78	84,61	8,15	84,57	8,51	85
86	85,79	6,01	85,76	6,37	85,74	6,75	85,71	7,12	85,67	7,50	85,64	7,87	85,61	8,24	85,57	8,61	86
87	86,79	6,07	86,76	6,45	86,73	6,83	86,70	7,21	86,67	7,58	86,63	7,96	86,60	8,34	86,56	8,71	87
88	87,79	6,14	87,76	6,52	87,73	6,91	87,70	7,29	87,67	7,67	87,63	8,05	87,60	8,44	87,56	8,81	88
89	88,78	6,21	88,76	6,60	88,73	6,98	88,70	7,37	88,66	7,76	88,63	8,14	88,59	8,53	88,55	8,91	89
90	89,78	6,28	89,75	6,67	89,72	7,06	89,69	7,45	89,66	7,84	89,62	8,24	89,59	8,63	89,55	9,01	90
91	90,78	6,35	90,75	6,74	90,72	7,14	90,69	7,54	90,65	7,93	90,62	8,33	90,58	8,72	90,54	9,11	91
92	91,78	6,42	91,75	6,82	91,72	7,22	91,68	7,62	91,65	8,02	91,61	8,42	91,58	8,82	91,54	9,21	92
93	92,77	6,49	92,75	6,89	92,71	7,30	92,68	7,70	92,65	8,11	92,61	8,51	92,57	8,92	92,53	9,31	93
94	93,77	6,56	93,74	6,97	93,71	7,38	93,68	7,78	93,64	8,19	93,61	8,60	93,57	9,01	93,53	9,41	94
95	94,77	6,63	94,74	7,04	94,71	7,45	94,67	7,87	94,64	8,28	94,60	8,69	94,56	9,11	94,52	9,51	95
96	95,77	6,70	95,74	7,12	95,71	7,53	95,67	7,95	95,63	8,37	95,60	8,78	95,56	9,20	95,52	9,61	96
97	96,76	6,77	96,73	7,19	96,70	7,61	96,67	8,03	96,63	8,45	96,59	8,88	96,55	9,30	96,51	9,71	97
98	97,76	6,84	97,73	7,26	97,70	7,69	97,66	8,12	97,63	8,54	97,59	8,97	97,55	9,39	97,51	9,81	98
99	98,76	6,91	98,73	7,34	98,70	7,77	98,66	8,20	98,62	8,63	98,59	9,06	98,55	9,49	98,50	9,91	99
100	99,76	6,98	99,73	7,41	99,69	7,85	99,66	8,28	99,62	8,72	99,58	9,15	99,54	9,59	99,50	10,01	100
101	100,7	7,05	100,7	7,49	100,7	7,92	100,6	8,36	100,6	8,80	100,6	9,24	100,5	9,68	100,5	10,11	101
102	101,7	7,12	101,7	7,56	101,7	8,00	101,6	8,45	101,6	8,89	101,6	9,33	101,5	9,78	101,5	10,21	102
103	102,7	7,19	102,7	7,63	102,7	8,08	102,6	8,53	102,6	8,98	102,6	9,43	102,5	9,87	102,5	10,32	103
104	103,7	7,26	103,7	7,71	103,7	8,16	103,6	8,61	103,6	9,07	103,6	9,52	103,5	9,97	103,5	10,42	104
105	104,7	7,33	104,7	7,78	104,7	8,24	104,6	8,70	104,6	9,15	104,6	9,61	104,5	10,06	104,5	10,52	105
106	105,7	7,40	105,7	7,86	105,7	8,32	105,6	8,78	105,5	9,24	105,5	9,70	105,5	10,16	105,5	10,62	106
107	106,7	7,46	106,7	7,93	106,7	8,40	106,6	8,86	106,5	9,33	106,5	9,79	106,5	10,26	106,5	10,72	107
108	107,7	7,53	107,7	8,00	107,7	8,47	107,6	8,94	107,5	9,41	107,5	9,88	107,5	10,35	107,5	10,82	108
109	108,7	7,60	108,7	8,08	108,7	8,55	108,6	9,03	108,5	9,50	108,5	9,97	108,5	10,45	108,5	10,92	109
110	109,7	7,67	109,7	8,15	109,7	8,63	109,6	9,11	109,5	9,59	109,5	10,07	109,5	10,54	109,4	11,02	110
111	110,7	7,74	110,7	8,23	110,7	8,71	110,6	9,19	110,5	9,68	110,5	10,16	110,5	10,64	110,4	11,12	111
112	111,7	7,81	111,7	8,30	111,7	8,79	111,6	9,28	111,5	9,76	111,5	1					

TRAVERSE TABLE, 712.

315

Distance	6 Degree								7 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,67	6,38	60,64	6,64	60,61	6,91	60,58	7,17	60,55	7,43	60,51	7,70	60,48	7,96	60,44	8,23	61
62	61,66	6,48	61,63	6,78	61,60	7,02	61,57	7,29	61,54	7,56	61,50	7,82	61,47	8,09	61,43	8,36	62
63	62,66	6,59	62,63	6,86	62,60	7,13	62,56	7,41	62,53	7,68	62,50	7,95	62,46	8,22	62,42	8,50	63
64	63,65	6,69	63,62	6,97	63,59	7,24	63,56	7,52	63,52	7,80	63,49	8,08	63,45	8,35	63,42	8,63	64
65	64,64	6,80	64,61	7,08	64,58	7,36	64,55	7,64	64,52	7,92	64,48	8,20	64,44	8,48	64,41	8,77	65
66	65,64	6,90	65,61	7,19	65,58	7,47	65,55	7,76	65,51	8,04	65,47	8,33	65,44	8,62	65,40	8,90	66
67	66,63	7,01	66,60	7,29	66,57	7,58	66,54	7,88	66,50	8,17	66,46	8,45	66,43	8,75	66,39	9,04	67
68	67,63	7,11	67,60	7,40	67,56	7,70	67,53	7,99	67,49	8,29	67,46	8,58	67,42	8,88	67,38	9,17	68
69	68,62	7,21	68,59	7,51	68,56	7,81	68,52	8,11	68,49	8,41	68,45	8,71	68,41	9,01	68,37	9,31	69
70	69,62	7,32	69,58	7,62	69,55	7,92	69,52	8,23	69,48	8,53	69,44	8,83	69,40	9,14	69,36	9,44	70
71	70,61	7,42	70,58	7,73	70,54	8,04	70,51	8,35	70,47	8,65	70,43	8,96	70,39	9,27	70,35	9,58	71
72	71,61	7,53	71,57	7,84	71,54	8,15	71,50	8,46	71,46	8,77	71,42	9,09	71,38	9,40	71,34	9,71	72
73	72,60	7,63	72,57	7,95	72,53	8,26	72,49	8,58	72,46	8,90	72,42	9,21	72,37	9,53	72,33	9,84	73
74	73,59	7,74	73,56	8,06	73,52	8,38	73,49	8,70	73,45	9,02	73,41	9,34	73,37	9,66	73,32	9,98	74
75	74,59	7,84	74,56	8,17	74,52	8,49	74,48	8,82	74,44	9,14	74,40	9,46	74,36	9,79	74,32	10,11	75
76	75,58	7,94	75,55	8,27	75,51	8,60	75,47	8,93	75,44	9,26	75,39	9,59	75,35	9,92	75,31	10,25	76
77	76,58	8,05	76,54	8,38	76,51	8,72	76,47	9,05	76,43	9,38	76,38	9,72	76,34	10,05	76,30	10,38	77
78	77,57	8,15	77,54	8,49	77,40	8,83	77,46	9,17	77,42	9,51	77,38	9,84	77,33	10,18	77,29	10,52	78
79	78,57	8,26	78,53	8,61	78,49	8,94	78,45	9,29	78,41	9,63	78,37	9,97	78,32	10,31	78,28	10,65	79
80	79,56	8,36	79,53	8,71	79,49	9,06	79,45	9,40	79,40	9,75	79,36	10,09	79,32	10,44	79,27	10,79	80
81	80,56	8,47	80,52	8,82	80,48	9,17	80,44	9,52	80,39	9,87	80,35	10,22	80,31	10,57	80,26	10,92	81
82	81,55	8,57	81,51	8,93	81,47	9,28	81,43	9,64	81,38	9,99	81,34	10,35	81,30	10,70	81,25	11,06	82
83	82,55	8,68	82,51	9,04	82,47	9,40	82,43	9,76	82,38	10,12	82,34	10,48	82,29	10,83	82,24	11,19	83
84	83,54	8,78	83,50	9,15	83,46	9,51	83,42	9,87	83,37	10,24	83,33	10,60	83,28	10,96	83,23	11,33	84
85	84,53	8,88	84,50	9,25	84,45	9,62	84,41	9,99	84,37	10,36	84,32	10,73	84,27	11,10	84,22	11,46	85
86	85,53	8,99	85,49	9,36	85,45	9,73	85,40	10,11	85,36	10,48	85,31	10,85	85,26	11,23	85,22	11,60	86
87	86,52	9,09	86,48	9,47	86,44	9,85	86,40	10,23	86,35	10,60	86,30	10,98	86,26	11,36	86,21	11,73	87
88	87,52	9,20	87,48	9,58	87,43	9,96	87,39	10,34	87,34	10,73	87,30	11,11	87,25	11,49	87,20	11,87	88
89	88,51	9,30	88,47	9,69	88,43	10,07	88,38	10,46	88,34	10,85	88,29	11,23	88,24	11,62	88,19	12,00	89
90	89,51	9,41	89,47	9,80	89,42	10,19	89,38	10,58	89,33	10,97	89,28	11,36	89,23	11,75	89,18	12,14	90
91	90,50	9,51	90,46	9,91	90,41	10,30	90,37	10,70	90,32	11,09	90,27	11,49	90,22	11,88	90,17	12,27	91
92	91,50	9,62	91,45	10,02	91,41	10,41	91,36	10,81	91,31	11,21	91,26	11,61	91,21	12,01	91,16	12,41	92
93	92,49	9,72	92,45	10,13	92,40	10,53	92,36	10,93	92,31	11,33	92,26	11,74	92,20	12,14	92,15	12,54	93
94	93,49	9,83	93,44	10,23	93,40	10,64	93,35	11,05	93,30	11,46	93,25	11,86	93,20	12,27	93,14	12,68	94
95	94,48	9,93	94,44	10,34	94,39	10,75	94,34	11,17	94,29	11,58	94,24	11,99	94,19	12,40	94,13	12,81	95
96	95,47	10,04	95,43	10,45	95,38	10,87	95,34	11,28	95,29	11,70	95,23	12,12	95,18	12,53	95,12	12,95	96
97	96,47	10,14	96,42	10,56	96,38	10,98	96,33	11,40	96,28	11,82	96,22	12,24	96,17	12,66	96,11	13,08	97
98	97,46	10,24	97,42	10,67	97,37	11,09	97,32	11,52	97,27	11,94	97,22	12,37	97,16	12,79	97,11	13,22	98
99	98,46	10,35	98,41	10,78	98,36	11,21	98,31	11,64	98,26	12,07	98,21	12,49	98,15	12,92	98,10	13,35	99
100	99,45	10,45	99,41	10,89	99,36	11,32	99,31	11,75	99,26	12,19	99,20	12,62	99,14	13,05	99,09	13,49	100
101	101,4	10,56	101,4	11,00	101,4	11,43	100,3	11,87	101,2	12,31	100,2	12,75	101,1	13,18	100,1	13,62	101
102	102,4	10,66	102,4	11,11	102,3	11,55	101,3	11,99	102,2	12,43	101,2	12,87	102,1	13,31	101,1	13,75	102
103	103,4	10,77	103,4	11,21	103,3	11,66	102,3	12,11	103,2	12,55	102,2	13,00	103,1	13,45	102,1	13,89	103
104	104,4	10,87	104,4	11,32	104,3	11,77	103,3	12,22	104,2	12,68	103,2	13,13	104,1	13,58	103,1	14,02	104
105	105,4	10,98	105,4	11,43	105,3	11,89	104,3	12,34	105,2	12,80	104,2	13,28	105,1	13,71	104,0	14,16	105
106	106,4	11,08	106,4	11,54	106,3	12,00	105,3	12,46	106,2	12,92	105,2	13,38	106,1	13,84	105,0	14,30	106
107	107,4	11,18	107,4	11,65	107,3	12,11	106,3	12,58	107,2	13,04	106,1	13,50	107,1	13,97	106,0	14,43	107
108	108,4	11,29	108,4	11,76	108,3	12,23	107,3	12,69	108,2	13,16	107,1	13,63	108,1	14,10	107,0	14,56	108
109	109,4	11,39	109,3	11,87	109,3	12,34	108,2	12,81	109,2	13,28							

TRAVERSE TABLE, 712.

Distance	8 Degrees.								9 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,99	0,14	0,99	0,14	0,99	0,15	0,99	0,15	0,99	0,26	0,99	0,16	0,99	0,17	0,99	0,17	1
2	1,98	0,28	1,98	0,29	1,98	0,30	1,98	0,30	1,98	0,31	1,97	0,32	1,97	0,33	1,97	0,34	2
3	2,97	0,42	2,97	0,43	2,97	0,44	2,97	0,46	2,96	0,47	2,96	0,48	2,96	0,50	2,96	0,51	3
4	3,96	0,56	3,96	0,57	3,96	0,59	3,95	0,61	3,95	0,63	3,95	0,64	3,95	0,66	3,94	0,68	4
5	4,95	0,70	4,95	0,72	4,95	0,74	4,94	0,76	4,94	0,78	4,94	0,80	4,93	0,83	4,92	0,85	5
6	5,94	0,84	5,94	0,86	5,93	0,88	5,93	0,91	5,93	0,94	5,92	0,96	5,92	0,99	5,91	1,02	6
7	6,93	0,97	6,93	1,00	6,92	1,04	6,92	1,07	6,91	1,10	6,91	1,13	6,90	1,16	6,89	1,19	7
8	7,92	1,11	7,92	1,15	7,91	1,18	7,91	1,22	7,90	1,25	7,90	1,29	7,89	1,32	7,88	1,36	8
9	8,91	1,25	8,91	1,29	8,90	1,33	8,90	1,37	8,89	1,41	8,88	1,45	8,88	1,49	8,86	1,52	9
10	9,90	1,39	9,90	1,44	9,89	1,48	9,88	1,52	9,88	1,56	9,87	1,61	9,86	1,65	9,84	1,70	10
11	10,90	1,53	10,89	1,58	10,88	1,63	10,87	1,67	10,87	1,72	10,86	1,77	10,85	1,82	10,85	1,86	11
12	11,89	1,67	11,88	1,72	11,87	1,77	11,86	1,83	11,85	1,88	11,84	1,93	11,84	1,98	11,83	2,03	12
13	12,88	1,81	12,87	1,87	12,86	1,92	12,85	1,98	12,84	2,03	12,83	2,09	12,82	2,15	12,80	2,20	13
14	13,87	1,95	13,86	2,01	13,85	2,07	13,84	2,13	13,83	2,19	13,82	2,25	13,81	2,31	13,79	2,37	14
15	14,86	2,09	14,85	2,15	14,84	2,22	14,83	2,28	14,82	2,35	14,81	2,41	14,79	2,48	14,78	2,54	15
16	15,84	2,23	15,84	2,30	15,82	2,37	15,81	2,44	15,80	2,50	15,79	2,57	15,78	2,64	15,77	2,71	16
17	16,83	2,37	16,83	2,44	16,81	2,51	16,80	2,59	16,79	2,66	16,78	2,73	16,77	2,81	16,75	2,88	17
18	17,82	2,51	17,81	2,58	17,80	2,66	17,79	2,74	17,78	2,82	17,77	2,89	17,75	2,97	17,74	3,05	18
19	18,81	2,64	18,80	2,73	18,79	2,81	18,78	2,89	18,77	2,97	18,75	3,05	18,74	3,14	18,73	3,22	19
20	19,81	2,78	19,79	2,87	19,78	2,96	19,77	3,04	19,75	3,13	19,74	3,22	19,73	3,30	19,71	3,39	20
21	20,79	2,92	20,78	3,01	20,77	3,10	20,76	3,19	20,74	3,29	20,73	3,38	20,71	3,47	20,70	3,56	21
22	21,78	3,06	21,77	3,16	21,76	3,25	21,74	3,35	21,73	3,44	21,71	3,54	21,70	3,63	21,68	3,73	22
23	22,77	3,21	22,76	3,30	22,75	3,40	22,73	3,50	22,72	3,60	22,70	3,70	22,69	3,80	22,67	3,90	23
24	23,76	3,34	23,75	3,44	23,74	3,55	23,72	3,65	23,71	3,76	23,69	3,86	23,67	3,96	23,65	4,07	24
25	24,75	3,48	24,74	3,59	24,73	3,70	24,71	3,80	24,69	3,91	24,68	4,02	24,66	4,13	24,64	4,24	25
26	25,74	3,62	25,73	3,73	25,71	3,84	25,70	3,95	25,68	4,07	25,66	4,18	25,64	4,29	25,62	4,40	26
27	26,73	3,76	26,72	3,87	26,70	3,99	26,69	4,11	26,67	4,22	26,65	4,34	26,63	4,46	26,61	4,57	27
28	27,72	3,90	27,71	4,02	27,69	4,14	27,67	4,26	27,66	4,38	27,64	4,50	27,61	4,62	27,60	4,74	28
29	28,71	4,04	28,70	4,16	28,68	4,29	28,66	4,41	28,64	4,54	28,62	4,66	28,60	4,79	28,58	4,91	29
30	29,71	4,18	29,69	4,31	29,67	4,43	29,65	4,56	29,63	4,69	29,61	4,82	29,59	4,96	29,57	5,08	30
31	30,70	4,31	30,68	4,45	30,66	4,58	30,64	4,72	30,62	4,85	30,60	4,98	30,58	5,12	30,55	5,25	31
32	31,69	4,45	31,67	4,59	31,65	4,73	31,63	4,87	31,61	5,01	31,58	5,14	31,56	5,29	31,54	5,42	32
33	32,68	4,59	32,66	4,74	32,64	4,88	32,62	5,02	32,59	5,16	32,57	5,31	32,55	5,45	32,52	5,59	33
34	33,67	4,73	33,65	4,88	33,63	5,03	33,61	5,17	33,58	5,32	33,56	5,47	33,53	5,62	33,51	5,76	34
35	34,66	4,87	34,64	5,02	34,62	5,17	34,59	5,33	34,57	5,48	34,55	5,63	34,52	5,78	34,49	5,93	35
36	35,65	5,01	35,63	5,17	35,61	5,33	35,58	5,48	35,56	5,63	35,54	5,79	35,51	5,95	35,48	6,10	36
37	36,64	5,15	36,62	5,31	36,59	5,47	36,57	5,63	36,55	5,79	36,53	5,95	36,49	6,11	36,47	6,27	37
38	37,63	5,29	37,61	5,45	37,58	5,62	37,56	5,78	37,53	5,95	37,52	6,11	37,48	6,28	37,45	6,44	38
39	38,62	5,43	38,60	5,60	38,57	5,76	38,55	5,93	38,52	6,10	38,49	6,27	38,47	6,44	38,44	6,61	39
40	39,61	5,57	39,59	5,74	39,56	5,91	39,53	6,09	39,51	6,26	39,48	6,43	39,45	6,61	39,42	6,77	40
41	40,60	5,71	40,58	5,88	40,55	6,06	40,52	6,24	40,50	6,41	40,47	6,59	40,44	6,77	40,41	6,94	41
42	41,59	5,85	41,57	6,03	41,54	6,21	41,51	6,39	41,48	6,57	41,45	6,75	41,43	6,94	41,39	7,11	42
43	42,58	5,99	42,56	6,17	42,53	6,36	42,50	6,54	42,47	6,73	42,44	6,91	42,41	7,10	42,38	7,28	43
44	43,57	6,13	43,55	6,31	43,52	6,50	43,49	6,69	43,46	6,88	43,43	7,07	43,40	7,27	43,36	7,45	44
45	44,56	6,26	44,54	6,46	44,51	6,60	44,48	6,8	44,45	7,04	44,42	7,23	44,38	7,43	44,35	7,62	45
46	45,55	6,40	45,52	6,60	45,50	6,80	45,46	7,00	45,43	7,20	45,40	7,40	45,37	7,60	45,34	7,79	46
47	46,54	6,54	46,51	6,74	46,48	6,95	46,45	7,15	46,42	7,35	46,39	7,56	46,36	7,76	46,32	7,96	47
48	47,53	6,68	47,50	6,89	47,47	7,09	47,44	7,30	47,41	7,51	47,38	7,72	47,34	7,93	47,31	8,13	48
49	48,52	6,82	48,49	7,03	48,46	7,24	48,43	7,45	48,40	7,66	48,36	7,88	48,33	8,09	48,29	8,30	49
50	49,51	6,96	49,48	7,18	49,45	7,39	49,42	7,61	49,39	7,82	49,35	8,04	49,32	8,26	49,28	8,47	50
51	50,50	7,10	50,47	7,32	50,44	7,54	50,41	7,76	50,37	7,98	50,32	8,20	50,30	8,42	50,26	8,64	51
52	51,49	7,24	51,46	7,46	51,43	7,69	51,40	7,91	51,36	8,14	51,34	8,36	51,29	8,59	51,25	8,81	52
53	52,48	7,38	52,45	7,61	52,42	7,83	52,38	8,06	52,35	8,29	52,31	8,52	52,27	8,75	52,24	8,98	53
54	53,47	7,52	53,44	7,75	53,41	7,98	53,37	8,21	53,34	8,45	53,30	8,68	53,26	8,92	53,22	9,15	54
55	54,47	7,66	54,43	7,89	54,40	8,13	54,36	8,37	54,32	8,60	54,29	8,84	54,25	9,08	54,21	9,32	55
56	55,46	7,79	55,42	8,04	55,39	8,28	55,35	8,52	55,31	8,76	55,27	9,00	55,23	9,25	55,19	9,48	56
57	56,45	7,93	56,41	8,18	56,37	8,43	56,34	8,67	56,30	8,92	56,26	9,16	56,22	9,41	56,18	9,65	57
58	57,44	8,07	57,40	8,32	57,36	8,57	57,33	8,82	57,29	9,07	57,25	9,32	57,21	9,58	57,16	9,82	58
59	58,43	8,21	58,39	8,47	58,35	8,72	58,31	8,98	58,28	9,23	58,23	9,48	58,19	9,74	58,15	9,99	59
60	59,42	8,35	59,38	8,61	59,34	8,87	59,30	9,13	59,26	9,39	59,22	9,62	59,18	9,91	59,13	10,16	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	82 Deg.				81 Degrees				80 Degrees								

317

Distance	8 Degrees								9 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,41	8,49	60,37	8,75	60,33	9,02	60,29	9,28	60,25	9,54	60,21	9,81	60,16	10,07	60,12	10,33	61
62	61,40	8,63	61,36	8,90	61,32	9,16	61,28	9,43	61,24	9,70	61,19	9,97	61,15	10,24	61,11	10,50	62
63	62,39	8,77	62,35	9,04	62,31	9,31	62,27	9,58	62,22	9,86	62,18	10,13	62,14	10,40	62,09	10,67	63
64	63,38	8,91	63,34	9,18	63,30	9,46	63,26	9,74	63,21	10,01	63,17	10,29	63,12	10,57	63,08	10,84	64
65	64,37	9,05	64,33	9,33	64,29	9,61	64,24	9,89	64,20	10,17	64,16	10,45	64,11	10,74	64,06	11,01	65
66	65,36	9,19	65,32	9,47	65,28	9,76	65,23	10,04	65,19	10,33	65,14	10,61	65,09	10,90	65,05	11,18	66
67	66,35	9,32	66,31	9,61	66,26	9,90	66,22	10,19	66,18	10,48	66,13	10,77	66,08	11,07	66,03	11,35	67
68	67,34	9,46	67,30	9,76	67,25	10,05	67,21	10,34	67,16	10,64	67,12	10,93	67,07	11,23	67,02	11,52	68
69	68,33	9,60	68,29	9,90	68,24	10,20	68,20	10,50	68,15	10,79	68,10	11,09	68,05	11,40	68,00	11,69	69
70	69,32	9,74	69,28	10,04	69,23	10,35	69,19	10,65	69,14	10,95	69,09	11,25	69,04	11,56	68,99	11,86	70
71	70,31	9,88	70,27	10,19	70,22	10,50	70,17	10,80	70,13	11,11	70,08	11,41	70,03	11,73	69,97	12,02	71
72	71,30	10,02	71,26	10,33	71,21	10,64	71,16	10,95	71,11	11,26	71,06	11,57	71,01	11,89	70,96	12,19	72
73	72,29	10,16	72,25	10,47	72,20	10,79	72,15	11,10	72,10	11,42	72,05	11,74	72,00	12,06	71,95	12,36	73
74	73,28	10,30	73,23	10,62	73,19	10,94	73,14	11,26	73,09	11,58	73,04	11,90	72,99	12,22	72,93	12,52	74
75	74,27	10,44	74,22	10,76	74,18	11,09	74,13	11,41	74,08	11,73	74,03	12,06	73,97	12,39	73,92	12,79	75
76	75,26	10,58	75,21	10,91	75,17	11,24	75,11	11,56	75,07	11,89	75,01	12,22	74,96	12,55	74,90	12,87	76
77	76,25	10,72	76,20	11,05	76,15	11,38	76,10	11,71	76,05	12,05	76,00	12,38	75,94	12,72	75,89	13,04	77
78	77,24	10,86	77,19	11,19	77,14	11,53	77,09	11,86	77,04	12,20	76,99	12,54	76,93	12,88	76,87	13,21	78
79	78,23	10,99	78,18	11,34	78,13	11,68	78,08	12,02	78,03	12,36	77,97	12,70	77,92	13,05	77,86	13,38	79
80	79,22	11,13	79,17	11,48	79,12	11,83	79,07	12,17	79,02	12,51	78,96	12,86	78,90	13,21	78,85	13,55	80
81	80,21	11,27	80,16	11,62	80,11	11,97	80,06	12,32	80,00	12,67	79,95	13,02	79,89	13,38	79,83	13,72	81
82	81,20	11,41	81,15	11,77	81,10	12,12	81,05	12,47	80,99	12,83	80,93	13,18	80,88	13,54	80,82	13,89	82
83	82,19	11,55	82,14	11,91	82,09	12,27	82,03	12,63	81,98	12,98	81,92	13,34	81,86	13,71	81,80	14,06	83
84	83,18	11,69	83,13	12,05	83,08	12,42	83,02	12,78	82,97	13,14	82,91	13,50	82,85	13,87	82,79	14,23	84
85	84,17	11,83	84,12	12,20	84,07	12,56	84,01	12,93	83,95	13,30	83,90	13,66	83,83	14,04	83,77	14,40	85
86	85,16	11,97	85,11	12,34	85,06	12,72	85,00	13,08	84,94	13,45	84,88	13,82	84,82	14,20	84,76	14,57	86
87	86,15	12,11	86,10	12,48	86,05	12,86	85,99	13,23	85,93	13,61	85,87	13,99	85,81	14,37	85,74	14,73	87
88	87,14	12,25	87,09	12,63	87,03	13,01	86,98	13,39	86,92	13,77	86,86	14,15	86,79	14,53	86,73	14,90	88
89	88,13	12,39	88,08	12,77	88,02	13,16	87,97	13,54	87,91	13,92	87,84	14,31	87,78	14,70	87,71	15,07	89
90	89,12	12,53	89,07	12,91	89,01	13,30	88,95	13,69	88,89	14,08	88,83	14,47	88,77	14,86	88,70	15,24	90
91	90,11	12,67	90,06	13,06	90,00	13,45	89,94	13,84	89,88	14,24	89,82	14,63	89,75	15,03	89,69	15,41	91
92	91,10	12,80	91,05	13,20	90,99	13,60	90,93	14,00	90,87	14,39	90,80	14,79	90,74	15,19	90,67	15,58	92
93	92,10	12,94	92,04	13,34	91,98	13,75	91,92	14,15	91,86	14,55	91,79	14,95	91,73	15,36	91,66	15,75	93
94	93,09	13,08	93,03	13,49	92,97	13,89	92,91	14,30	92,84	14,71	92,78	15,11	92,71	15,52	92,64	15,92	94
95	94,08	13,22	94,02	13,63	93,96	14,04	93,89	14,45	93,83	14,86	93,77	15,27	93,70	15,69	93,63	16,09	95
96	95,07	13,36	95,01	13,78	94,95	14,19	94,88	14,60	94,82	15,02	94,75	15,43	94,68	15,86	94,61	16,26	96
97	96,06	13,50	96,00	13,92	95,94	14,34	95,87	14,76	95,81	15,17	95,74	15,59	95,67	16,02	95,60	16,43	97
98	97,05	13,64	96,99	14,06	96,92	14,49	96,86	14,91	96,79	15,33	96,73	15,75	96,66	16,19	96,58	16,60	98
99	98,04	13,78	97,98	14,21	97,91	14,63	97,85	15,06	97,78	15,49	97,71	15,91	97,64	16,35	97,57	16,77	99
100	99,03	13,92	98,97	14,35	98,90	14,78	98,84	15,21	98,77	15,64	98,70	16,07	98,63	16,52	98,56	16,94	100
101	100,0	14,06	99,96	14,49	99,89	14,93	99,83	15,36	99,76	15,80	99,69	16,24	99,62	16,68	99,55	17,11	101
102	101,0	14,20	100,9	14,64	100,9	15,08	100,8	15,52	100,7	15,96	100,7	16,40	100,6	16,85	100,5	17,27	102
103	102,0	14,33	101,9	14,78	101,9	15,22	101,8	15,67	101,7	16,11	101,7	16,56	101,6	17,01	101,5	17,44	103
104	103,0	14,47	102,9	14,92	102,9	15,37	102,8	15,82	102,7	16,27	102,6	16,72	102,6	17,18	102,5	17,61	104
105	104,0	14,61	103,9	15,07	103,8	15,52	103,8	15,97	103,7	16,43	103,6	16,88	103,6	17,34	103,5	17,78	105
106	105,0	14,75	104,9	15,21	104,8	15,67	104,8	16,12	104,7	16,58	104,6	17,04	104,6	17,51	104,5	17,95	106
107	106,0	14,89	105,9	15,35	105,8	15,82	105,8	16,28	105,7	16,74	105,6	17,20	105,5	17,67	105,5	18,12	107
108	106,9	15,03	106,9	15,50	106,8	15,96	106,7	16,43	106,7	16,90	106,6	17,36	106,5	17,84	106,4	18,29	108
109	107,9	15,17	107,9	15,64	107,8	16,11	107,7	16,58	107,7	17,05	107,6	17,52	107,5	18,00	107,4	18,46	109
110	108,9	15,31	108,9	15,78	108,8	16,26	108,7	16,73	108,6	17,21	108,6	17,68	108,5	18,17	108,4	18,63	110
111	109,9	15,45	109,9	15,93	109,8	16,41	109,7	16,89	109,6	17,36	109,6	17,84	109,5	18,33	109,4	18,80	111
112	110,9	15,59	110,8	16,07	110,8	16,56	110,7	7,04	110,6	17,52	110,5	18,00	110,5	18,50	110,4	18,97	112
113	111,9	15,73	111,8	16,21	111,8	16,70	111,7	17,19	111,6	17,68	111,5	18,16	111,5	18,66	111,4	19,14	113
114	112,9	15,87	112,8	16,36	112,7	16,85	112,7	17,34	112,6	17,83	112,5	18,32	112,4	18,83	112,4	19,31	114
115	113,9	16,01	113,8	16,50	113,7	17,00	113,7	17,49	113,6	17,99	113,5	18,49	113,4	18,99	113,3	19,48	115
116	114,9	16,14	114,8	16,65	114,7	17,15	114,7	17,65	114,6	18,15	114,5	18,65	114,4	19,16	114,3	19,65	116
117	115,9	16,28	115,8	16,79	115,7	17,30	115,6	17,80	115,6	18,30	115,5	18,81	115,4	19,32	115,3	19,81	117
118	116,9	16,42	116,8	16,93	116,7	17,44	116,6	17,95	116,5	18,46	116,5	18,97	116,4	19,49	116,3	19,98	118
119	117,8	16,56	117,8	17,08	117,7	17,59	117,6	18,10	117,5	18,62	117,5	19,13	117,4	19,65	117,3	20,15	119
120	118,8	16,70	118,8	17,22	118,7	17,74	118,6	18,25	118,5	18,77	118,4	19,29	118,4	19,81	118,3	20,31	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	2 Deg				81 Degrees				80 Degrees								

10 Degrees																	11 Degrees																																	
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance																																		
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.																																			
1	1,00	0,17	0,98	0,18	0,98	0,18	0,98	0,19	0,98	0,19	0,98	0,20	0,98	0,20	0,98	0,20	1																																	
2	1,97	0,35	1,97	0,36	1,97	0,36	1,97	0,37	1,96	0,38	1,96	0,39	1,96	0,40	1,96	0,41	2																																	
3	2,95	0,52	2,95	0,53	2,95	0,55	2,95	0,56	2,95	0,57	2,94	0,59	2,94	0,60	2,94	0,61	3																																	
4	3,94	0,70	3,94	0,71	3,93	0,73	3,93	0,75	3,93	0,76	3,92	0,78	3,92	0,80	3,92	0,82	4																																	
5	4,92	0,87	4,92	0,89	4,92	0,91	4,91	0,93	4,91	0,95	4,90	0,98	4,90	1,00	4,90	1,02	5																																	
6	5,91	1,04	5,90	1,07	5,90	1,09	5,90	1,12	5,89	1,15	5,89	1,17	5,88	1,20	5,87	1,22	6																																	
7	6,89	1,22	6,89	1,25	6,88	1,28	6,88	1,31	6,87	1,34	6,87	1,37	6,86	1,40	6,85	1,43	7																																	
8	7,88	1,39	7,87	1,42	7,87	1,46	7,86	1,49	7,85	1,53	7,85	1,56	7,84	1,60	7,83	1,63	8																																	
9	8,86	1,56	8,86	1,60	8,85	1,64	8,84	1,68	8,84	1,72	8,83	1,76	8,82	1,79	8,81	1,83	9																																	
10	9,85	1,74	9,84	1,78	9,83	1,82	9,83	1,87	9,82	1,91	9,81	1,95	9,80	1,99	9,79	2,04	10																																	
11	10,83	1,91	10,82	1,96	10,82	2,01	10,81	2,05	10,80	2,10	10,79	2,15	10,78	2,19	10,77	2,24	11																																	
12	11,82	2,08	11,81	2,14	11,80	2,19	11,79	2,24	11,78	2,29	11,77	2,34	11,76	2,39	11,75	2,44	12																																	
13	12,80	2,26	12,79	2,31	12,78	2,37	12,77	2,43	12,76	2,48	12,75	2,54	12,74	2,59	12,73	2,65	13																																	
14	13,78	2,43	13,78	2,49	13,77	2,55	13,75	2,61	13,74	2,67	13,73	2,73	13,72	2,79	13,71	2,85	14																																	
15	14,77	2,61	14,76	2,67	14,75	2,73	14,74	2,80	14,73	2,86	14,71	2,93	14,70	2,99	14,69	3,06	15																																	
16	15,76	2,78	15,74	2,85	15,73	2,92	15,72	2,98	15,71	3,05	15,69	3,12	15,68	3,19	15,67	3,26	16																																	
17	16,74	2,95	16,73	3,03	16,72	3,10	16,70	3,17	16,69	3,24	16,67	3,32	16,66	3,39	16,64	3,46	17																																	
18	17,73	3,13	17,71	3,20	17,70	3,28	17,68	3,36	17,67	3,43	17,65	3,51	17,64	3,59	17,62	3,66	18																																	
19	18,71	3,30	18,70	3,38	18,69	3,46	18,67	3,54	18,65	3,63	18,64	3,71	18,62	3,79	18,60	3,87	19																																	
20	19,70	3,47	19,68	3,56	19,67	3,65	19,65	3,73	19,63	3,82	19,62	3,90	19,60	3,99	19,58	4,07	20																																	
21	20,68	3,65	20,67	3,74	20,65	3,83	20,63	3,92	20,62	4,01	20,60	4,10	20,58	4,19	20,56	4,28	21																																	
22	21,67	3,82	21,65	3,92	21,63	4,01	21,61	4,10	21,60	4,20	21,58	4,29	21,56	4,39	21,54	4,48	22																																	
23	22,65	3,99	22,63	4,09	22,61	4,19	22,60	4,29	22,58	4,39	22,56	4,49	22,54	4,59	22,52	4,68	23																																	
24	23,64	4,17	23,62	4,27	23,60	4,37	23,58	4,48	23,56	4,58	23,54	4,68	23,52	4,78	23,50	4,89	24																																	
25	24,62	4,34	24,60	4,45	24,58	4,56	24,56	4,66	24,54	4,77	24,52	4,88	24,50	4,98	24,48	5,09	25																																	
26	25,61	4,51	25,59	4,63	25,56	4,74	25,54	4,85	25,52	4,96	25,50	5,07	25,48	5,18	25,46	5,30	26																																	
27	26,59	4,69	26,57	4,81	26,55	4,92	26,53	5,04	26,50	5,15	26,48	5,27	26,46	5,38	26,43	5,50	27																																	
28	27,57	4,86	27,55	4,98	27,53	5,10	27,51	5,22	27,49	5,34	27,46	5,46	27,44	5,58	27,41	5,70	28																																	
29	28,56	5,04	28,54	5,16	28,51	5,29	28,49	5,41	28,47	5,53	28,44	5,66	28,42	5,78	28,39	5,91	29																																	
30	29,54	5,21	29,52	5,34	29,50	5,47	29,47	5,60	29,45	5,72	29,42	5,85	29,40	5,98	29,37	6,11	30																																	
31	30,53	5,38	30,51	5,52	30,48	5,65	30,46	5,78	30,43	5,92	30,41	6,05	30,38	6,18	30,35	6,31	31																																	
32	31,51	5,56	31,49	5,69	31,46	5,83	31,44	5,97	31,41	6,11	31,39	6,24	31,36	6,38	31,33	6,52	32																																	
33	32,50	5,73	32,47	5,87	32,45	6,01	32,42	6,16	32,39	6,30	32,37	6,44	32,34	6,58	32,31	6,72	33																																	
34	33,48	5,91	33,46	6,05	33,43	6,20	33,40	6,34	33,38	6,49	33,35	6,63	33,32	6,78	33,29	6,92	34																																	
35	34,47	6,08	34,44	6,23	34,41	6,38	34,39	6,53	34,36	6,68	34,33	6,83	34,30	6,98	34,27	7,13	35																																	
36	35,45	6,25	35,43	6,41	35,40	6,56	35,37	6,72	35,34	6,87	35,31	7,02	35,28	7,18	35,25	7,33	36																																	
37	36,44	6,43	36,41	6,58	36,38	6,74	36,35	6,90	36,32	7,06	36,29	7,22	36,26	7,38	36,23	7,53	37																																	
38	37,42	6,60	37,39	6,76	37,36	6,93	37,33	7,09	37,30	7,25	37,27	7,41	37,24	7,58	37,20	7,74	38																																	
39	38,41	6,77	38,38	6,94	38,35	7,11	38,32	7,28	38,28	7,44	38,25	7,61	38,22	7,78	38,18	7,94	39																																	
40	39,39	6,95	39,36	7,12	39,33	7,29	39,30	7,46	39,27	7,63	39,23	7,80	39,20	7,98	39,16	8,15	40																																	
41	40,38	7,12	40,35	7,30	40,31	7,47	40,28	7,65	40,25	7,82	40,21	8,00	40,18	8,17	40,14	8,35	41																																	
42	41,36	7,29	41,33	7,47	41,30	7,65	41,26	7,83	41,23	8,01	41,19	8,19	41,16	8,37	41,12	8,55	42																																	
43	42,35	7,47	42,31	7,65	42,28	7,84	42,25	8,02	42,21	8,20	42,17	8,39	42,14	8,57	42,10	8,76	43																																	
44	43,33	7,64	43,30	7,83	43,26	8,02	43,23	8,21	43,19	8,40	43,16	8,58	43,12	8,77	43,08	8,96	44																																	
45	44,32	7,81	44,28	8,01	44,25	8,20	44,21	8,39	44,17	8,59	44,14	8,78	44,10	8,97	44,06	9,16	45																																	
46	45,30	7,99	45,27	8,19	45,23	8,38	45,19	8,58	45,16	8,78	45,12	8,97	45,08	9,17	45,04	9,37	46																																	
47	46,29	8,16	46,25	8,36	46,21	8,57	46,18	8,77	46,14	8,97	46,10	9,17	46,06	9,37	46,02	9,57	47																																	
48	47,27	8,33	47,23	8,54	47,20	8,75	47,16	8,95	47,12	9,16	47,08	9,37	47,04	9,57	47,00	9,78	48																																	
49	48,26	8,51	48,22	8,72	48,18	8,93	48,14	9,14	48,10	9,35	48,06	9,56	48,02	9,77	47,97	9,98	49																																	
50	49,24	8,68	49,20	8,90	49,16	9,11	49,12	9,33	49,08	9,54	49,04	9,76	49,00	9,97	48,95	10,18	50																																	
51	50,23	8,86	50,19	9,08	50,15	9,29	50,11	9,51	50,06	9,73	50,02	9,95	49,98	10,17	49,93	10,39	51																																	
52	51,21	9,03	51,17	9,25	51,13	9,48	51,09	9,70	51,05	9,92	51,00	10,15	50,96	10,37	50,91	10,59	52																																	
53	52,20	9,20	52,15	9,43	52,11	9,66	52,07	9,89	52,03	10,11	51,98	10,34	51,94	10,57	51,89	10,79	53																																	
54	53,18	9,38	53,14	9,61	53,10	9,84	53,05	10,07	53,01	10,30	52,96	10,54	52,92	1,077	52,87	11,00	54																																	
55	54,17	9,55	54,12	9,79	54,08	10,02	54,04	10,26	53,99	10,50	53,94	10,73	53,90	10,97	53,85	11,20	55																																	
56	55,15	9,75	55,11	9,97	55,06	10,21	55,02	10,45	54,97	10,69	54,93	10,93	54,88	11,17	54,83	11,40	56																																	
57	56,14	9,90	56,09	10,14	56,05	10,39	56,00	10,63	55,95	10,88	55,91	11,12	55,86	11,37	55,81	11,61	57																																	
58	57,12	10,07	57,07	10,32	57,03	10,57	56,98	10,82	56,94	11,07	56,89	11,32	56,84	11,56	56,79	11,81	58																																	
59	58,10	10,25	58,06	10,50	58,01	10,75	57,97	11,01	57,92	11,26	57,87	11,51	57,82	11,76	57,76	12,02	59																																	
60	59,09	10,42	59,04	10,68	59,09	10,93	58,95	11,19	58,90	11,45	58,85	11,71	58,80	11,96	58,74	12,22	60																																	
Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Distance																																		
0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		Distance																																		
80 Deg.																	79 Degrees																	78 Degrees																

TRAVERSE TABLE 712.

319

Distance	10 Degrees								11 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	60,07	10,59	60,03	10,85	59,98	11,12	59,93	11,38	58,93	11,64	59,83	11,90	59,78	12,16	59,72	12,41	61
62	61,06	10,77	61,01	11,03	60,96	11,30	60,91	11,56	60,86	11,83	60,81	12,09	60,76	12,36	60,70	12,63	62
63	62,04	10,94	61,99	11,21	61,94	11,48	61,89	11,75	61,84	12,02	61,79	12,29	61,74	12,56	61,68	12,83	63
64	63,03	11,11	62,98	11,39	62,93	11,66	62,88	11,94	62,83	12,21	62,77	12,49	62,72	12,76	62,66	13,03	64
65	64,01	11,29	63,96	11,57	63,91	11,85	63,86	12,12	63,81	12,40	63,75	12,68	63,70	12,96	63,64	13,21	65
66	65,00	11,46	64,95	11,74	64,89	12,03	64,84	12,31	64,79	12,59	64,73	12,88	64,68	13,16	64,62	13,44	66
67	65,98	11,64	65,93	11,92	65,88	12,21	65,82	12,50	65,77	12,79	65,71	13,07	65,66	13,36	65,60	13,64	67
68	66,97	11,81	66,91	12,10	66,86	12,39	66,81	12,68	66,75	12,98	66,59	13,27	66,64	13,56	66,58	13,85	68
69	67,95	11,98	67,90	12,28	67,84	12,57	67,79	12,87	67,73	13,17	67,67	13,46	67,61	13,76	67,55	14,05	69
70	68,94	12,16	68,88	12,46	68,83	12,76	68,77	13,06	68,71	13,36	68,66	13,66	68,59	13,96	68,53	14,26	70
71	69,92	12,38	69,87	12,63	69,81	12,94	69,75	13,24	69,70	13,55	69,64	13,85	69,57	14,16	69,51	14,46	71
72	70,91	12,50	70,85	12,81	70,79	13,12	70,74	13,43	70,68	13,74	70,62	14,05	70,55	14,36	70,49	14,66	72
73	71,89	12,68	71,84	12,99	71,73	13,30	71,72	13,61	71,66	13,93	71,60	14,24	71,53	14,55	71,47	14,87	73
74	72,88	12,85	72,82	13,17	72,76	13,49	72,70	13,80	72,64	14,12	72,58	14,44	72,51	14,75	72,45	15,07	74
75	73,86	13,02	73,80	13,35	73,74	13,67	73,68	13,99	73,62	14,31	73,56	14,63	73,49	14,95	73,43	15,27	75
76	74,85	13,20	74,79	13,52	74,73	13,85	74,67	14,18	74,60	14,50	74,54	14,83	74,47	15,15	74,41	15,48	76
77	75,83	13,37	75,77	13,70	75,71	14,03	75,65	14,36	75,59	14,69	75,52	15,02	75,45	15,35	75,39	15,68	77
78	76,82	13,54	76,76	13,88	76,69	14,22	76,63	14,55	76,57	14,88	76,50	15,22	76,43	15,55	76,37	15,88	78
79	77,80	13,72	77,74	14,06	77,68	14,40	77,61	14,74	77,55	15,07	77,48	15,41	77,41	15,75	77,35	16,09	79
80	78,79	13,89	78,72	14,24	78,66	14,58	78,60	14,92	78,53	15,27	78,46	15,61	78,39	15,95	78,32	16,29	80
81	79,77	14,07	79,71	14,41	79,64	14,76	79,58	15,11	79,51	15,46	79,44	15,80	79,37	16,15	79,30	16,50	81
82	80,76	14,24	80,69	14,59	80,63	14,94	80,56	15,30	80,49	15,65	80,43	16,00	80,35	16,35	80,28	16,70	82
83	81,74	14,41	81,68	14,77	81,61	15,13	81,54	15,48	81,48	15,84	81,41	16,19	81,33	16,55	81,26	16,90	83
84	82,72	14,59	82,66	14,95	82,59	15,31	82,53	15,67	82,46	16,03	82,39	16,39	82,31	16,75	82,24	17,11	84
85	83,73	14,76	83,64	15,13	83,58	15,49	83,51	15,86	83,44	16,22	83,37	16,58	83,29	16,95	83,22	17,31	85
86	84,71	14,93	84,63	15,30	84,56	15,67	84,49	16,04	84,42	16,41	84,35	16,78	84,27	17,15	84,20	17,51	86
87	85,60	15,11	85,61	15,48	85,54	15,85	85,47	16,23	85,40	16,60	85,33	16,97	85,25	17,35	85,18	17,72	87
88	86,68	15,28	86,60	15,66	86,53	16,04	86,46	16,41	86,38	16,79	86,31	17,17	86,23	17,55	86,16	17,92	88
89	87,67	15,46	87,58	15,84	87,51	16,22	87,44	16,60	87,37	16,98	87,29	17,36	87,21	17,74	87,14	18,12	89
90	88,65	15,62	88,56	16,02	88,49	16,40	88,42	16,79	88,35	17,17	88,27	17,56	88,19	17,94	88,12	18,38	90
91	89,62	15,80	89,55	16,19	89,48	16,53	89,40	16,97	89,33	17,36	89,25	17,75	89,17	18,14	89,09	18,53	91
92	90,60	15,98	90,53	16,37	90,46	16,77	90,39	17,16	90,31	17,56	90,23	17,95	90,15	18,34	90,07	18,74	92
93	91,59	16,15	91,52	16,55	91,44	16,95	91,37	17,35	91,29	17,75	91,21	18,14	91,13	18,54	91,05	18,94	93
94	92,57	16,32	92,50	16,73	92,43	17,13	92,35	17,53	92,27	17,94	92,19	18,34	92,11	18,74	92,03	19,14	94
95	93,56	16,50	93,48	16,91	93,41	17,31	93,33	17,72	93,26	18,13	93,18	18,54	93,09	18,94	93,01	19,35	95
96	94,54	16,67	94,47	17,08	94,39	17,50	94,32	17,91	94,24	18,32	94,16	18,73	94,07	19,14	93,99	19,55	96
97	95,53	16,85	95,45	17,26	95,38	17,68	95,30	18,09	95,22	18,51	95,14	18,92	95,05	19,34	94,97	19,75	97
98	96,51	17,02	96,44	17,44	96,36	17,86	96,28	18,28	96,20	18,70	96,12	19,12	96,03	19,54	95,95	19,96	98
99	97,50	17,19	97,42	17,62	97,34	18,04	97,26	18,47	97,18	18,89	97,10	19,31	97,01	19,74	96,93	20,16	99
100	98,48	17,37	98,40	17,79	98,33	18,22	98,25	18,65	98,16	19,08	98,08	19,51	97,99	19,94	97,91	20,36	100
101	99,47	17,54	99,39	17,97	99,31	18,41	99,23	18,84	99,15	19,27	99,06	19,70	98,97	20,14	98,88	20,57	101
102	100,4	17,71	100,4	18,15	100,3	18,59	100,2	19,03	100,1	19,46	100,0	19,90	99,95	20,34	99,86	20,77	102
103	101,4	17,89	101,4	18,33	101,3	18,77	101,2	19,21	102,1	19,65	101,0	20,09	100,9	20,54	100,8	20,98	103
104	102,4	18,06	102,3	18,51	102,3	18,95	102,2	19,40	103,1	19,84	102,0	20,29	101,9	20,73	101,8	21,18	104
105	103,4	18,23	103,3	18,68	103,2	19,14	103,2	19,59	104,0	20,04	103,0	20,48	102,9	20,93	102,8	21,38	105
106	104,3	18,41	104,3	18,86	104,2	19,32	104,1	19,77	105,0	20,23	104,0	20,68	103,9	21,13	103,8	21,59	106
107	105,3	18,58	105,3	19,04	105,2	19,50	105,1	19,96	106,0	20,42	104,9	20,88	104,8	21,33	104,8	21,79	107
108	106,3	18,75	106,3	19,22	106,2	19,68	106,1	20,14	107,0	20,61							

TRAVERSE TABLE, 712.

12 Degrees										13 Degrees									
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.					
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.				
1	0,98	0,21	0,98	0,21	0,98	0,22	0,98	0,21	0,97	0,23	0,97	0,23	0,97	0,23	0,97	0,24			
2	1,96	0,42	1,95	0,42	1,95	0,43	1,95	0,44	1,95	0,45	1,95	0,46	1,95	0,47	1,94	0,48			
3	2,93	0,62	2,93	0,64	2,93	0,65	2,93	0,66	2,92	0,68	2,92	0,69	2,92	0,70	2,91	0,71			
4	3,91	0,83	3,91	0,85	3,91	0,87	3,90	0,88	3,90	0,90	3,89	0,92	3,89	0,93	3,89	0,95			
5	4,89	1,04	4,89	1,06	4,88	1,08	4,88	1,10	4,87	1,13	4,87	1,15	4,86	1,17	4,86	1,19			
6	5,87	1,25	5,86	1,27	5,86	0,30	5,85	1,32	5,85	1,35	5,84	1,38	5,83	1,40	5,83	1,43			
7	6,85	1,46	6,84	1,49	6,83	1,52	6,83	1,55	6,82	1,58	6,81	1,60	6,81	1,63	6,80	1,66			
8	7,83	1,66	7,82	1,70	7,81	1,73	7,80	1,77	7,80	1,80	7,79	1,83	7,78	1,87	7,77	1,90			
9	8,80	1,87	8,80	1,91	8,79	1,95	8,78	1,99	8,77	2,03	8,76	2,06	8,75	2,10	8,74	2,14			
10	9,78	2,08	9,77	2,12	9,76	2,16	9,75	2,21	9,74	2,25	9,73	2,29	9,72	2,34	9,71	2,38			
11	10,76	2,29	10,75	2,33	10,74	2,38	10,73	2,43	10,72	2,47	10,71	2,52	10,70	2,57	10,69	2,62			
12	11,74	2,50	11,73	2,55	11,72	2,60	11,70	2,65	11,69	2,70	11,68	2,75	11,67	2,80	11,66	2,85			
13	12,72	2,70	12,71	2,76	12,69	2,81	12,68	2,87	12,67	2,92	12,65	2,98	12,64	3,03	12,63	3,09			
14	13,70	2,91	13,68	2,97	13,67	3,03	13,66	3,09	13,64	3,15	13,63	3,21	13,61	3,27	13,60	3,33			
15	14,67	3,12	14,66	3,18	14,65	3,25	14,63	3,31	14,62	3,37	14,60	3,44	14,59	3,50	14,57	3,57			
16	15,65	3,33	15,64	3,40	15,62	3,46	15,61	3,53	15,59	3,60	15,57	3,67	15,56	3,74	15,54	3,80			
17	16,63	3,53	16,61	3,61	16,60	3,68	16,58	3,75	16,57	3,82	16,55	3,90	16,53	3,97	16,51	4,04			
18	17,61	3,74	17,59	3,82	17,57	3,90	17,56	3,97	17,54	4,05	17,52	4,13	17,50	4,20	17,48	4,28			
19	18,59	3,95	18,57	4,03	18,55	4,11	18,53	4,19	18,51	4,27	18,49	4,36	18,48	4,44	18,46	4,52			
20	19,56	4,16	19,55	4,24	19,53	4,33	19,51	4,41	19,49	4,50	19,47	4,58	19,45	4,67	19,43	4,75			
21	20,54	4,37	20,52	4,46	20,50	4,55	20,48	4,64	20,46	4,72	20,44	4,81	20,42	4,90	20,40	4,99			
22	21,52	4,57	21,50	4,67	21,48	4,76	21,46	4,86	21,44	4,95	21,42	5,04	21,39	5,14	21,37	5,23			
23	22,50	4,78	22,48	4,88	22,46	4,98	22,43	5,08	22,41	5,17	22,39	5,27	22,36	5,37	22,34	5,47			
24	23,48	4,99	23,45	5,09	23,43	5,20	23,41	5,30	23,38	5,40	23,36	5,50	23,34	5,60	23,31	5,71			
25	24,45	5,20	24,43	5,31	24,41	5,41	24,39	5,51	24,36	5,62	24,34	5,73	24,31	5,84	24,28	5,94			
26	25,43	5,41	25,41	5,52	25,38	5,63	25,36	5,74	25,33	5,85	25,31	5,96	25,28	6,07	25,26	6,18			
27	26,41	5,61	26,39	5,73	26,36	5,85	26,34	5,96	26,31	6,07	26,28	6,19	26,25	6,30	26,23	6,42			
28	27,39	5,82	27,36	5,94	27,34	6,06	27,31	6,18	27,28	6,30	27,26	6,42	27,23	6,54	27,20	6,66			
29	28,37	6,03	28,34	6,15	28,31	6,28	28,29	6,40	28,26	6,52	28,23	6,65	28,20	6,77	28,17	6,89			
30	29,35	6,24	29,32	6,37	29,29	6,49	29,26	6,62	29,23	6,75	29,20	6,88	29,17	7,00	29,14	7,13			
31	30,32	6,45	30,29	6,58	30,27	6,71	30,24	6,84	30,21	6,97	30,17	7,11	30,14	7,24	30,11	7,37			
32	31,30	6,65	31,27	6,79	31,24	6,93	31,21	7,06	31,18	7,20	31,15	7,33	31,12	7,47	31,08	7,61			
33	32,28	6,86	32,25	7,00	32,22	7,14	32,19	7,28	32,15	7,42	32,12	7,56	32,09	7,70	32,05	7,84			
34	33,26	7,07	33,23	7,21	33,19	7,36	33,16	7,50	33,13	7,65	33,10	7,79	33,06	7,94	33,03	8,08			
35	34,24	7,28	34,20	7,43	34,17	7,58	34,14	7,73	34,10	7,87	34,07	8,02	34,03	8,17	34,00	8,32			
36	35,21	7,48	35,18	7,64	35,15	7,79	35,11	7,95	35,08	8,10	35,04	8,25	35,01	8,41	34,97	8,56			
37	36,19	7,69	36,16	7,85	36,12	8,01	36,09	8,17	36,05	8,32	36,02	8,48	35,98	8,64	35,94	8,80			
38	37,17	7,90	37,14	8,06	37,10	8,23	37,06	8,39	37,03	8,55	36,99	8,71	36,95	8,87	36,91	9,03			
39	38,15	8,11	38,11	8,28	38,08	8,44	38,04	8,61	38,00	8,77	37,96	8,94	37,92	9,11	37,88	9,27			
40	39,13	8,32	39,09	8,48	39,05	8,66	39,01	8,83	38,98	9,00	38,94	9,17	38,90	9,34	38,85	9,51			
41	40,10	8,52	40,07	8,70	40,03	8,88	39,99	9,05	39,95	9,22	39,91	9,40	39,87	9,57	39,83	9,75			
42	41,08	8,73	41,04	8,91	41,01	9,09	40,97	9,27	40,92	9,45	40,88	9,63	40,84	9,81	40,80	9,98			
43	42,06	8,94	42,02	9,12	41,98	9,31	41,94	9,49	41,90	9,67	41,86	9,86	41,81	10,04	41,77	10,22			
44	43,04	9,15	43,00	9,34	42,96	9,52	42,92	9,71	42,87	9,90	42,83	10,09	42,78	10,27	42,74	10,46			
45	44,02	9,36	43,98	9,55	43,93	9,74	43,89	9,93	43,85	10,12	43,80	10,31	43,76	10,51	43,71	10,70			
46	45,00	9,56	44,95	9,76	44,91	9,96	44,87	10,15	44,82	10,35	44,78	10,54	44,73	10,74	44,68	10,93			
47	45,97	9,77	45,93	9,97	45,89	10,17	45,84	10,37	45,80	10,57	45,75	10,77	45,70	10,97	45,65	11,17			
48	46,95	9,98	46,91	10,19	46,86	10,39	46,82	10,59	46,77	10,80	46,72	11,00	46,67	11,21	46,63	11,41			
49	47,93	10,19	47,88	10,40	47,84	10,61	47,79	10,81	47,74	11,02	47,70	11,23	47,65	11,44	47,60	11,65			
50	48,91	10,40	48,86	10,61	48,82	10,82	48,77	11,04	48,72	11,25	48,67	11,46	48,62	11,67	48,57	11,89			
51	49,89	10,60	49,84	10,82	49,79	11,04	49,74	11,26	49,69	11,47	49,64	11,69	49,59	11,91	49,54	12,12			
52	50,86	10,81	50,82	11,03	50,77	11,26	50,72	11,48	50,67	11,70	50,62	11,92	50,56	12,14	50,51	12,36			
53	51,84	11,02	51,79	11,25	51,74	11,47	51,69	11,70	51,64	11,92	51,59	12,15	51,54	12,37	51,48	12,6			
54	52,82	11,23	52,77	11,46	52,72	11,69	52,67	11,92	52,62	12,15	52,56	12,38	52,51	12,61	52,45	12,84			
55	53,80	11,44	53,75	11,67	53,70	11,91	53,65	12,14	53,59	12,37	53,54	12,61	53,48	12,84	53,42	13,07			
56	54,78	11,64	54,73	11,88	54,67	12,12	54,62	12,36	54,57	12,60	54,51	12,84	54,45	13,07	54,40	13,3			
57	55,76	11,85	55,70	12,09	55,65	12,34	55,60	12,58	55,54	12,82	55,48	13,06	55,43	13,31	55,37	13,5			
58	56,73	12,06	56,68	12,31	56,63	12,55	56,57	12,80	56,51	13,05	56,46	13,29	56,40	13,54	56,34	13,79			
59	57,71	12,27	57,66	12,52	57,60	12,77	57,55	13,02	57,49	13,27	57,43	13,52	57,37	13,77	57,31	14,82			
60	58,69	12,48	58,63	12,73	58,58	12,99	58,52	13,24	58,46	13,50	58,40	13,75	58,34	14,01	58,28	14,76			
Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Dep.			
0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		0 Min.			
78 Deg.						77 Degrees										76 Degrees			

TRAVERSE TABLE, 712.

321

Distance	12 Degrees								13 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	59,67	12,68	59,61	12,94	59,55	13,20	59,50	13,46	59,44	13,72	59,38	13,98	59,31	14,24	59,25	14,50	61
62	60,65	12,89	60,59	13,16	60,53	13,42	60,47	13,68	60,41	13,95	60,35	14,21	60,29	14,47	60,22	14,74	62
63	61,62	13,10	61,57	13,37	61,51	13,64	61,45	13,90	61,38	14,17	61,32	14,44	61,26	14,71	61,19	14,97	63
64	62,60	13,31	62,54	13,58	62,48	13,85	62,42	14,13	62,36	14,40	62,30	14,67	62,23	14,94	62,17	15,21	64
65	63,58	13,52	63,52	13,79	63,46	14,07	63,40	14,35	63,33	14,62	63,27	14,90	63,20	15,17	63,14	15,45	65
66	64,56	13,72	64,50	14,00	64,44	14,29	64,37	14,57	64,31	14,85	64,24	15,13	64,18	15,41	64,11	15,69	66
67	65,54	13,93	65,48	14,22	65,41	14,50	65,35	14,79	65,28	15,07	65,22	15,36	65,15	15,64	65,08	15,93	67
68	66,51	14,14	66,45	14,43	66,39	14,72	66,32	15,01	66,26	15,30	66,19	15,59	66,12	15,88	66,05	16,16	68
69	67,49	14,35	67,43	14,64	67,37	14,93	67,30	15,23	67,23	15,52	67,16	15,82	67,09	16,11	67,02	16,40	69
70	68,47	14,55	68,41	14,85	68,34	15,15	68,27	15,45	68,21	15,75	68,14	16,04	68,07	16,34	67,99	16,64	70
71	69,45	14,76	69,38	15,07	69,32	15,37	69,25	15,67	69,18	15,97	69,11	16,27	69,04	16,58	68,97	16,88	71
72	70,43	14,97	70,36	15,28	70,29	15,58	70,23	15,89	70,15	16,20	70,08	16,50	70,01	16,81	69,94	17,11	72
73	71,41	15,18	71,34	15,49	71,27	15,80	71,20	16,11	71,13	16,42	71,06	16,73	70,98	17,04	70,91	17,35	73
74	72,38	15,39	72,32	15,70	72,25	16,02	72,18	16,33	72,10	16,65	72,03	16,96	71,96	17,28	71,88	17,59	74
75	73,36	15,59	73,29	15,91	73,22	16,23	73,15	16,55	73,08	16,87	73,00	17,19	72,93	17,51	72,85	17,82	75
76	74,34	15,80	74,27	16,13	74,20	16,45	74,13	16,77	74,05	17,10	73,98	17,42	73,90	17,74	73,82	18,06	76
77	75,32	16,01	75,25	16,34	75,18	16,67	75,10	16,99	75,03	17,32	74,95	17,65	74,87	17,98	74,79	18,30	77
78	76,30	16,22	76,22	16,55	76,16	16,88	76,08	17,22	76,00	17,55	75,92	17,88	75,85	18,21	75,77	18,54	78
79	77,27	16,43	77,20	16,76	77,13	17,10	77,05	17,44	76,97	17,77	76,90	18,11	76,82	18,44	76,74	18,78	79
80	78,25	16,63	78,18	16,97	78,10	17,32	78,03	17,66	77,95	18,00	77,87	18,34	77,79	18,68	77,71	19,02	80
81	79,23	16,84	79,16	17,19	79,08	17,53	79,00	17,88	78,92	18,22	78,84	18,57	78,76	18,91	78,68	19,25	81
82	80,21	17,05	80,13	17,40	80,06	17,75	79,98	18,10	79,90	18,45	79,82	18,79	79,74	19,14	79,65	19,49	82
83	81,19	17,26	81,11	17,61	81,03	17,97	80,95	18,32	80,87	18,67	80,79	19,02	80,71	19,38	80,62	19,73	83
84	82,16	17,47	82,09	17,82	82,01	18,18	81,93	18,54	81,85	18,90	81,76	19,25	81,68	19,61	81,59	19,97	84
85	83,14	17,67	83,06	18,04	82,99	18,40	82,91	18,76	82,82	19,12	82,74	19,48	82,65	19,84	82,56	20,20	85
86	84,12	17,88	84,04	18,25	83,96	18,61	83,88	18,98	83,80	19,35	83,71	19,71	83,62	20,08	83,54	20,44	86
87	85,10	18,09	85,02	18,46	84,94	18,83	84,86	19,20	84,77	19,57	84,68	19,94	84,60	20,31	84,51	20,68	87
88	86,08	18,30	86,00	18,67	85,92	19,05	85,83	19,42	85,74	19,80	85,66	20,17	85,57	20,54	85,48	20,92	88
89	87,06	18,50	86,97	18,84	86,89	19,26	86,81	19,64	86,72	20,02	86,63	20,40	86,54	20,78	86,45	21,15	89
90	88,03	18,71	87,95	19,10	87,87	19,48	87,78	19,86	87,69	20,25	87,60	20,63	87,51	21,01	87,42	21,39	90
91	89,01	18,92	88,93	19,31	88,84	19,70	88,76	20,08	88,67	20,47	88,58	20,86	88,49	21,24	88,39	21,63	91
92	89,99	19,13	89,91	19,52	89,82	19,91	89,73	20,30	89,64	20,69	89,55	21,08	89,46	21,48	89,36	21,87	92
93	90,97	19,34	90,88	19,73	90,80	20,13	90,71	20,53	90,62	20,92	90,52	21,32	90,43	21,71	90,34	22,11	93
94	91,95	19,55	91,86	19,95	91,77	20,36	91,68	20,75	91,59	21,14	91,50	21,55	91,40	21,95	91,31	22,34	94
95	92,93	19,75	92,84	20,16	92,75	20,56	92,66	20,97	92,56	21,37	92,47	21,77	92,38	22,18	92,28	22,58	95
96	93,90	19,96	93,81	20,37	93,73	20,78	93,63	21,19	93,54	21,59	93,44	22,00	93,35	22,41	93,25	22,82	96
97	94,88	20,17	94,79	20,58	94,70	21,00	94,61	21,41	94,51	21,82	94,42	22,23	94,32	22,65	94,22	23,05	97
98	95,86	20,38	95,77	20,79	95,68	21,21	95,59	21,63	95,49	22,04	95,39	22,46	95,29	22,88	95,19	23,29	98
99	96,84	20,58	96,75	21,01	96,66	21,43	96,56	21,85	96,46	22,27	96,36	22,69	96,26	23,11	96,16	23,53	99
100	97,82	20,79	97,73	21,22	97,63	21,64	97,53	22,07	97,44	22,49	97,34	22,92	97,24	23,35	97,13	23,77	100
101	98,79	21,00	98,70	21,43	98,61	21,86	98,51	22,29	98,41	22,72	98,31	23,15	98,21	23,58	98,11	24,01	101
102	99,77	21,21	99,68	21,64	99,58	22,08	99,49	22,51	99,39	22,94	99,29	23,38	99,18	23,81	99,08	24,24	102
103	101,7	21,42	100,7	21,86	100,6	22,29	100,5	22,73	100,4	23,17	100,3	23,61	100,2	24,05	100,0	24,48	103
104	102,7	21,62	101,6	22,07	101,5	22,51	101,4	22,95	101,3	23,39	101,2	23,84	101,1	24,28	101,0	24,72	104
105	103,7	21,83	102,6	22,28	102,5	22,73	102,4	23,17	102,3	23,62	102,2	24,07	102,1	24,51	102,0	24,96	105
106	104,7	22,04	103,6	22,49	103,5	22,94	103,4	23,39	103,3	23,84	103,2	24,30	103,1	24,75	103,0	25,20	106
107	105,6	22,25	104,6	22,70	104,5	23,16	104,4	23,62	104,3	24,07	104,2	24,52	104,0	24,98	104,9	25,44	107
108	106,6	22,45	105,5	22,92													

TRAVERSE TABLE, 712.

Distance	14 Degrees								15 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,97	0,24	0,97	0,25	0,97	0,25	0,97	0,25	0,97	0,26	0,96	0,26	0,96	0,27	0,96	0,27	1
2	1,94	0,48	1,94	0,49	1,94	0,50	1,93	0,51	1,93	0,52	1,93	0,53	1,93	0,53	1,92	0,54	2
3	2,91	0,73	2,91	0,74	2,90	0,75	2,90	0,76	2,90	0,78	2,89	0,79	2,89	0,80	2,89	0,81	3
4	3,88	0,97	3,88	0,98	3,87	1,00	3,87	1,02	3,86	1,03	3,86	1,05	3,85	1,07	3,85	1,09	4
5	4,85	1,21	4,85	1,23	4,84	1,25	4,83	1,27	4,83	1,29	4,82	1,31	4,82	1,34	4,81	1,36	5
6	5,82	1,45	5,81	1,48	5,81	1,50	5,80	1,53	5,80	1,55	5,79	1,58	5,78	1,60	5,77	1,63	6
7	6,79	1,69	6,78	1,72	6,78	1,75	6,77	1,78	6,76	1,81	6,75	1,84	6,74	1,87	6,74	1,90	7
8	7,76	1,93	7,75	1,97	7,74	2,00	7,74	2,04	7,73	2,07	7,72	2,10	7,71	2,14	7,70	2,17	8
9	8,73	2,18	8,72	2,21	8,71	2,25	8,70	2,29	8,69	2,33	8,68	2,37	8,67	2,40	8,66	2,44	9
10	9,70	2,42	9,69	2,46	9,68	2,50	9,67	2,55	9,66	2,59	9,65	2,63	9,64	2,67	9,62	2,71	10
11	10,67	2,66	10,66	2,71	10,65	2,75	10,64	2,80	10,62	2,85	10,61	2,89	10,60	2,94	10,59	2,99	11
12	11,64	2,90	11,63	2,95	11,62	3,00	11,60	3,05	11,59	3,11	11,58	3,16	11,56	3,21	11,55	3,26	12
13	12,61	3,14	12,60	3,20	12,59	3,25	12,57	3,31	12,56	3,36	12,54	3,42	12,53	3,47	12,51	3,53	13
14	13,58	3,39	13,57	3,45	13,55	3,51	13,54	3,56	13,52	3,62	13,51	3,68	13,49	3,74	13,47	3,80	14
15	14,55	3,63	14,54	3,69	14,52	3,76	14,51	3,82	14,49	3,88	14,47	3,94	14,45	4,01	14,44	4,07	15
16	15,52	3,87	15,51	3,94	15,49	4,01	15,47	4,07	15,45	4,14	15,44	4,21	15,42	4,28	15,40	4,34	16
17	16,49	4,11	16,48	4,18	16,46	4,26	16,44	4,33	16,42	4,40	16,40	4,47	16,38	4,54	16,36	4,61	17
18	17,46	4,35	17,45	4,43	17,43	4,51	17,41	4,58	17,39	4,66	17,37	4,75	17,34	4,81	17,32	4,89	18
19	18,44	4,60	18,42	4,68	18,39	4,76	18,37	4,84	18,35	4,91	18,33	5,00	18,31	5,08	18,29	5,16	19
20	19,41	4,84	19,38	4,92	19,36	5,01	19,34	5,09	19,32	5,18	19,30	5,26	19,27	5,34	19,25	5,43	20
21	20,38	5,08	20,35	5,17	20,33	5,26	20,31	5,35	20,28	5,43	20,26	5,52	20,24	5,61	20,21	5,70	21
22	21,35	5,32	21,32	5,41	21,30	5,51	21,27	5,60	21,25	5,69	21,23	5,79	21,20	5,88	21,17	5,97	22
23	22,32	5,56	22,29	5,66	22,27	5,76	22,24	5,86	22,21	5,95	22,19	6,05	22,16	6,15	22,14	6,24	23
24	23,29	5,81	23,26	5,91	23,24	6,01	23,21	6,11	23,18	6,21	23,15	6,31	23,13	6,41	23,10	6,51	24
25	24,26	6,05	24,23	6,15	24,20	6,26	24,17	6,36	24,15	6,47	24,12	6,58	24,09	6,68	24,06	6,79	25
26	25,23	6,29	25,20	6,40	25,17	6,51	25,14	6,62	25,11	6,73	25,08	6,84	25,05	6,95	25,02	7,06	26
27	26,20	6,53	26,17	6,65	26,14	6,76	26,11	6,88	26,08	6,99	26,05	7,10	26,02	7,22	25,99	7,33	27
28	27,17	6,77	27,14	6,89	27,11	7,01	27,08	7,13	27,05	7,25	27,01	7,36	26,98	7,48	26,95	7,60	28
29	28,14	7,01	28,11	7,14	28,08	7,26	28,04	7,38	28,01	7,51	27,98	7,63	27,95	7,75	27,91	7,87	29
30	29,11	7,26	29,08	7,38	29,04	7,51	29,01	7,64	28,98	7,76	28,94	7,89	28,91	8,02	28,87	8,14	30
31	30,08	7,50	30,05	7,63	30,01	7,76	29,98	7,89	29,94	8,02	29,91	8,15	29,87	8,28	29,84	8,41	31
32	31,05	7,74	31,02	7,88	30,98	8,01	30,95	8,15	30,91	8,28	30,87	8,42	30,84	8,55	30,80	8,69	32
33	32,02	7,98	31,99	8,12	31,95	8,26	31,91	8,40	31,88	8,54	31,84	8,68	31,80	8,82	31,76	8,96	33
34	32,99	8,23	32,95	8,37	32,92	8,51	32,88	8,66	32,84	8,80	32,80	8,94	32,76	9,09	32,72	9,23	34
35	33,96	8,47	33,92	8,62	33,89	8,76	33,85	8,91	33,81	9,06	33,77	9,21	33,73	9,35	33,69	9,50	35
36	34,93	8,71	34,89	8,86	34,85	9,01	34,81	9,17	34,77	9,32	34,73	9,47	34,69	9,62	34,65	9,77	36
37	35,90	8,95	35,86	9,11	35,82	9,26	35,78	9,42	35,74	9,58	35,70	9,73	35,65	9,89	35,61	10,04	37
38	36,87	9,19	36,83	9,35	36,79	9,51	36,75	9,67	36,71	9,84	36,66	9,99	36,62	10,15	36,57	10,31	38
39	37,84	9,44	37,80	9,60	37,76	9,76	37,71	9,93	37,67	10,09	37,63	10,26	37,58	10,42	37,54	10,59	39
40	38,81	9,68	38,77	9,85	38,73	10,01	38,68	10,18	38,64	10,35	38,59	10,52	38,54	10,69	38,50	10,86	40
41	39,78	9,92	39,74	10,09	39,69	10,27	39,65	10,44	39,60	10,61	39,56	10,78	39,51	10,96	39,46	11,13	41
42	40,75	10,16	40,71	10,34	40,66	10,52	40,62	10,69	40,57	10,87	40,52	11,05	40,47	11,22	40,42	11,40	42
43	41,72	10,40	41,68	10,58	41,63	10,77	41,58	10,95	41,53	11,13	41,49	11,31	41,44	11,49	41,39	11,67	43
44	42,69	10,64	42,65	10,83	42,60	11,02	42,55	11,20	42,50	11,39	42,45	11,57	42,40	11,76	42,35	11,94	44
45	43,66	10,89	43,62	11,08	43,57	11,27	43,52	11,46	43,47	11,65	43,42	11,84	43,36	12,03	43,31	12,22	45
46	44,63	11,13	44,58	11,32	44,53	11,52	44,48	11,72	44,43	11,91	44,38	12,10	44,33	12,29	44,27	12,49	46
47	45,60	11,37	45,55	11,57	45,50	11,76	45,45	11,96	45,40	12,16	45,35	12,36	45,29	12,56	45,24	12,76	47
48	46,57	11,61	46,52	11,81	46,47	12,02	46,42	12,22	46,36	12,42	46,31	12,62	46,25	12,83	46,20	13,03	48
49	47,54	11,85	47,49	12,06	47,44	12,27	47,38	12,47	47,33	12,68	47,27	12,89	47,22	13,09	47,16	13,30	49
50	48,51	12,10	48,46	12,31	48,41	12,52	48,35	12,73	48,30	12,94	48,24	13,15	48,18	13,36	48,12	13,57	50
51	49,48	12,34	49,43	12,55	49,38	12,77	49,32	12,98	49,26	13,20	49,20	13,41	49,15	13,62	49,09	13,84	51
52	50,46	12,58	50,40	12,80	50,34	13,02	50,29	13,24	50,23	13,46	50,17	13,68	50,11	13,90	50,05	14,11	52
53	51,43	12,82	51,37	13,05	51,31	13,27	51,25	13,49	51,19	13,72	51,13	13,94	51,07	14,16	51,01	14,39	53
54	52,40	13,06	52,34	13,29	52,28	13,52	52,22	13,75	52,16	13,98	52,10	14,20	52,04	14,43	51,97	14,66	54
55	53,37	13,31	53,31	13,54	53,25	13,77	53,19	14,00	53,13	14,23	53,06	14,47	53,00	14,70	52,94	14,98	55
56	54,34	13,55	54,28	13,78	54,22	14,02	54,15	14,26	54,09	14,49	54,03	14,73	53,96	14,96	53,90	15,20	56
57	55,31	13,79	55,25	14,03	55,18	14,27	55,12	14,51	55,06	14,75	54,99	14,99	54,93	15,23	54,86	15,47	57
58	56,28	14,03	56,22	14,28	56,15	14,52	56,09	14,77	56,02	15,01	55,96	15,26	55,89	15,50	55,82	15,74	58
59	57,25	14,27	57,19	14,52	57,12	14,77	57,06	15,02	56,99	15,27	56,92	15,52	56,85	15,77	56,79	16,02	59
60	58,21	14,51	58,15	14,77	58,09	15,02	58,02	15,28	57,96	15,53	57,89	15,78	57,82	16,03	57,75	16,29	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	70 Deg.						75 Degrees								74 Degrees		

Distance	14 Degrees								15 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	59,19	14,76	59,12	15,01	59,06	15,27	58,99	15,53	58,92	15,79	58,85	16,04	58,78	16,30	58,71	16,56	61
62	60,10	15,00	60,09	15,26	60,02	15,52	59,96	15,78	59,89	16,05	59,82	16,31	59,74	16,57	59,67	16,83	62
63	61,13	15,24	61,06	15,51	60,99	15,77	60,92	16,04	60,85	16,30	60,78	16,57	60,71	16,84	60,63	17,10	63
64	62,10	15,48	62,03	15,75	61,96	16,02	61,89	16,29	61,82	16,56	61,75	16,83	61,67	17,10	61,60	17,37	64
65	63,07	15,72	63,00	16,00	62,93	16,27	62,86	16,55	62,79	16,82	62,71	17,10	62,64	17,37	62,56	17,64	65
66	64,04	15,97	63,97	16,25	63,90	16,52	63,82	16,80	63,75	17,08	63,68	17,36	63,60	17,64	63,52	17,91	66
67	65,01	16,21	64,94	16,49	64,87	16,78	64,79	17,06	64,72	17,34	64,64	17,62	64,56	17,90	64,48	18,19	67
68	65,98	16,45	65,91	16,74	65,83	17,03	65,76	17,31	65,68	17,60	65,60	17,89	65,53	18,17	65,45	18,46	68
69	66,95	16,69	66,88	16,98	66,80	17,28	66,73	17,57	66,65	17,86	66,57	18,15	66,49	18,44	66,41	18,73	69
70	67,92	16,93	67,85	17,23	67,77	17,53	67,69	17,82	67,61	18,12	67,53	18,41	67,45	18,71	67,37	19,00	70
71	68,89	17,18	68,82	17,48	68,74	17,78	68,66	18,08	68,58	18,38	68,50	18,67	68,42	18,97	68,33	19,27	71
72	69,86	17,42	69,78	17,72	69,71	18,03	69,63	18,33	69,55	18,63	69,46	18,94	69,38	19,24	69,30	19,54	72
73	70,83	17,66	70,75	17,97	70,67	18,28	70,59	18,59	70,51	18,89	70,43	19,20	70,34	19,51	70,26	19,82	73
74	71,80	17,90	71,72	18,22	71,64	18,53	71,56	18,84	71,48	19,15	71,39	19,46	71,31	19,78	71,22	20,09	74
75	72,77	18,14	72,69	18,46	72,61	18,78	72,53	19,09	72,44	19,41	72,36	19,73	72,27	20,04	72,18	20,36	75
76	73,74	18,39	73,66	18,71	73,58	19,03	73,50	19,35	73,41	19,67	73,32	19,99	73,24	20,31	73,15	20,63	76
77	74,71	18,63	74,63	18,95	74,55	19,28	74,46	19,60	74,38	19,93	74,29	20,25	74,21	20,58	74,11	20,99	77
78	75,68	18,87	75,60	19,20	75,52	19,53	75,43	19,86	75,34	20,19	75,25	20,52	75,16	20,84	75,07	21,17	78
79	76,65	19,11	76,57	19,45	76,48	19,78	76,40	20,11	76,31	20,45	76,22	20,78	76,13	21,11	76,03	21,44	79
80	77,62	19,35	77,54	19,69	77,45	20,03	77,36	20,37	77,27	20,71	77,18	21,04	77,09	21,38	77,00	21,71	80
81	78,59	19,60	78,51	19,94	78,42	20,28	78,33	20,62	78,24	20,96	78,15	21,30	78,05	21,65	77,96	21,99	81
82	79,56	19,84	79,48	20,18	79,39	20,53	79,30	20,88	79,21	21,22	79,11	21,57	79,01	21,91	78,92	22,26	82
83	80,53	20,08	80,45	20,43	80,36	20,78	80,26	21,13	80,17	21,48	80,08	21,83	79,98	22,18	79,88	22,53	83
84	81,50	20,32	81,42	20,68	81,32	21,03	81,23	21,39	81,14	21,74	81,04	22,09	80,94	22,45	80,85	22,80	84
85	82,48	20,56	82,38	20,92	82,29	21,28	82,20	21,64	82,10	22,00	82,01	22,36	81,91	22,71	81,81	23,07	85
86	83,45	20,81	83,35	21,17	83,26	21,53	83,17	21,90	83,07	22,26	82,97	22,62	82,87	22,98	82,77	23,34	86
87	84,42	21,05	84,32	21,41	84,23	21,78	84,13	22,15	84,04	22,52	83,94	22,88	83,83	23,25	83,73	23,61	87
88	85,39	21,29	85,29	21,66	85,20	22,03	85,10	22,40	85,00	22,78	84,90	23,15	84,80	23,52	84,70	23,89	88
89	86,36	21,53	86,26	21,91	86,17	22,28	86,07	22,66	85,97	23,03	85,87	23,41	85,76	23,78	85,66	24,16	89
90	87,33	21,77	87,23	22,15	87,13	22,53	87,03	22,91	86,93	23,29	86,83	23,67	86,73	24,05	86,62	24,43	90
91	88,30	22,01	88,20	22,40	88,10	22,78	88,00	23,17	87,90	23,55	87,80	23,94	87,69	24,32	87,58	24,70	91
92	89,27	22,26	89,17	22,65	89,07	23,03	88,97	23,42	88,87	23,81	88,76	24,20	88,65	24,59	88,55	24,97	92
93	90,24	22,50	90,14	22,89	90,04	23,28	89,94	23,68	89,83	24,07	89,72	24,46	89,62	24,85	89,51	25,24	93
94	91,21	22,74	91,11	23,14	91,01	23,54	90,90	23,93	90,80	24,33	90,69	24,73	90,58	25,12	90,47	25,52	94
95	92,18	22,98	92,08	23,38	91,97	23,79	91,87	24,19	91,76	24,59	91,65	24,99	91,54	25,39	91,43	25,79	95
96	93,15	23,22	93,05	23,63	92,94	24,04	92,84	24,44	92,73	24,85	92,62	25,25	92,51	25,65	92,40	26,06	96
97	94,12	23,47	94,02	23,88	93,91	24,29	93,80	24,70	93,70	25,11	93,58	25,51	93,47	25,92	93,36	26,33	97
98	95,09	23,71	94,98	24,12	94,88	24,54	94,77	24,95	94,66	25,36	94,55	25,78	94,44	26,19	94,32	26,60	98
99	96,06	23,95	95,95	24,37	95,85	24,79	95,74	25,20	95,63	25,62	95,51	26,04	95,40	26,46	95,28	26,87	99
100	97,03	24,19	96,92	24,61	96,81	25,04	96,70	25,45	96,59	25,88	96,48	26,30	96,36	26,72	96,25	27,14	100
101	98,00	24,43	97,89	24,86	97,78	25,29	97,67	25,71	97,56	26,11	97,44	26,57	97,33	26,99	97,21	27,42	101
102	98,97	24,68	98,86	25,11	98,75	25,54	98,64	25,97	98,52	26,40	98,41	26,83	98,29	27,26	98,17	27,69	102
103	99,94	24,92	99,83	25,35	99,71	25,79	99,61	26,22	99,49	26,66	99,37	27,09	99,25	27,53	99,13	27,96	103
104	100,9	25,16	100,8	25,60	100,7	26,04	100,6	26,48	100,5	26,92	100,3	27,35	100,2	27,79	100,1	28,23	104
105	101,9	25,40	101,8	25,86	101,7	26,29	101,5	26,73	101,4	27,18	101,3	27,62	101,2	28,06	101,1	28,50	105
106	102,9	25,64	102,7	26,09	102,6	26,54	102,5	26,99	102,4	27,43	102,3	27,88	102,1	28,33	102,0	28,77	106
107	103,8	25,88	103,7	26,34	103,6	26,79	103,5	27,24	103,4	27,69	103,2	28,14	103,1	28,59	103,0	29,04	107
108	104,8	26,13	104,7	26,58	104,6	27,04	104										

TRAVERSE TABLE, 712.

16 Degrees																	17 Degrees																
Distance	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		Distance																
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.																	
1	0,96	0,28	0,96	0,28	0,96	0,28	0,96	0,29	0,96	0,29	0,96	0,30	0,95	0,30	0,95	0,31	1																
2	1,92	0,51	1,92	0,56	1,92	0,57	1,92	0,58	1,91	0,59	1,91	0,59	1,91	0,60	1,91	0,61	2																
3	2,88	0,83	2,88	0,84	2,88	0,85	2,87	0,87	2,87	0,88	2,87	0,89	2,86	0,90	2,86	0,92	3																
4	3,84	1,10	3,84	1,12	3,84	1,14	3,83	1,15	3,83	1,17	3,82	1,19	3,82	1,20	3,81	1,22	4																
5	4,80	1,38	4,80	1,40	4,79	1,42	4,79	1,44	4,77	1,46	4,78	1,48	4,77	1,50	4,76	1,52	5																
6	5,77	1,65	5,76	1,68	5,75	1,70	5,75	1,73	5,74	1,75	5,73	1,78	5,72	1,80	5,71	1,83	6																
7	6,73	1,93	6,72	1,96	6,71	1,99	6,70	2,02	6,69	2,05	6,69	2,08	6,68	2,11	6,67	2,13	7																
8	7,69	2,21	7,68	2,24	7,67	2,27	7,66	2,31	7,65	2,34	7,64	2,37	7,63	2,41	7,62	2,44	8																
9	8,65	2,48	8,64	2,52	8,63	2,56	8,62	2,59	8,61	2,63	8,60	2,67	8,58	2,71	8,57	2,74	9																
10	9,61	2,76	9,60	2,80	9,59	2,84	9,58	2,86	9,56	2,92	9,55	2,97	9,54	3,01	9,52	3,05	10																
11	10,57	3,03	10,56	3,08	10,55	3,12	10,53	3,17	10,52	3,22	10,51	3,26	10,49	3,31	10,48	3,35	11																
12	11,54	3,31	11,52	3,36	11,51	3,41	11,49	3,46	11,48	3,51	11,46	3,56	11,45	3,61	11,43	3,66	12																
13	12,50	3,58	12,48	3,64	12,46	3,69	12,45	3,75	12,43	3,81	12,42	3,86	12,40	3,91	12,38	3,96	13																
14	13,46	3,86	13,44	3,92	13,42	3,98	13,41	4,04	13,39	4,09	13,37	4,15	13,35	4,21	13,33	4,27	14																
15	14,42	4,13	14,40	4,20	14,38	4,26	14,36	4,33	14,35	4,39	14,33	4,45	14,31	4,51	14,29	4,57	15																
16	15,38	4,41	15,36	4,48	15,34	4,54	15,32	4,61	15,30	4,68	15,28	4,74	15,26	4,81	15,24	4,88	16																
17	16,34	4,69	16,32	4,76	16,30	4,83	16,28	4,90	16,26	4,97	16,24	5,04	16,21	5,11	16,19	5,18	17																
18	17,30	4,96	17,28	5,04	17,26	5,11	17,23	5,19	17,21	5,26	17,19	5,34	17,17	5,41	17,14	5,49	18																
19	18,26	5,24	18,24	5,32	18,22	5,40	18,19	5,48	18,17	5,56	18,15	5,63	18,12	5,71	18,10	5,79	19																
20	19,23	5,51	19,20	5,60	19,18	5,68	19,15	5,76	19,13	5,85	19,10	5,93	19,07	6,01	19,05	6,10	20																
21	20,19	5,79	20,16	5,88	20,14	5,96	20,11	6,05	20,08	6,14	20,06	6,23	20,03	6,31	20,00	6,40	21																
22	21,15	6,06	21,12	6,16	21,09	6,25	21,07	6,34	21,04	6,43	21,01	6,52	20,98	6,62	20,95	6,71	22																
23	22,11	6,34	22,08	6,44	22,05	6,53	22,02	6,63	22,00	6,72	21,97	6,82	21,94	6,92	21,91	7,01	23																
24	23,07	6,62	23,04	6,72	23,01	6,82	22,98	6,92	22,95	7,02	22,92	7,12	22,89	7,22	22,86	7,32	24																
25	24,03	6,89	24,00	7,00	23,97	7,10	23,94	7,21	23,91	7,31	23,88	7,41	23,84	7,52	23,81	7,62	25																
26	24,99	7,17	24,96	7,28	24,93	7,38	24,90	7,49	24,86	7,60	24,83	7,71	24,80	7,82	24,76	7,93	26																
27	25,95	7,44	25,92	7,56	25,89	7,67	25,85	7,78	25,82	7,89	25,79	8,01	25,75	8,12	25,72	8,23	27																
28	26,91	7,72	26,88	7,84	26,85	7,95	26,81	8,07	26,78	8,19	26,74	8,30	26,70	8,42	26,67	8,54	28																
29	27,88	7,99	27,84	8,12	27,81	8,24	27,77	8,36	27,73	8,48	27,70	8,60	27,66	8,72	27,62	8,84	29																
30	28,84	8,27	28,80	8,40	28,77	8,52	28,73	8,65	28,69	8,77	28,65	8,90	28,61	9,02	28,57	9,15	30																
31	29,80	8,55	29,76	8,68	29,72	8,81	29,68	8,93	29,65	9,06	29,61	9,19	29,57	9,32	29,52	9,45	31																
32	30,76	8,82	30,72	8,96	30,69	9,09	30,64	9,22	30,60	9,36	30,56	9,49	30,52	9,62	30,48	9,76	32																
33	31,72	9,10	31,68	9,23	31,64	9,37	31,60	9,51	31,56	9,65	31,52	9,79	31,47	9,92	31,43	10,06	33																
34	32,68	9,37	32,64	9,51	32,60	9,66	32,56	9,80	32,51	9,94	32,47	10,08	32,42	10,22	32,38	10,37	34																
35	33,64	9,65	33,60	9,79	33,56	9,94	33,51	10,09	33,47	10,23	33,43	10,38	33,38	10,53	33,33	10,67	35																
36	34,61	9,92	34,56	10,07	34,52	10,23	34,47	10,38	34,43	10,53	34,38	10,68	34,33	10,83	34,29	10,97	36																
37	35,57	10,20	35,52	10,35	35,48	10,51	35,43	10,66	35,38	10,82	35,34	10,97	35,29	11,13	35,24	11,28	37																
38	36,53	10,47	36,48	10,63	36,44	10,79	36,39	10,95	36,34	11,11	36,29	11,27	36,24	11,43	36,19	11,58	38																
39	37,49	10,75	37,44	10,91	37,39	11,08	37,35	11,24	37,30	11,40	37,25	11,56	37,20	11,73	37,14	11,89	39																
40	38,45	11,03	38,40	11,19	38,35	11,36	38,30	11,53	38,25	11,7	38,20	11,86	38,15	12,03	38,10	12,19	40																
41	39,41	11,30	39,36	11,47	39,31	11,65	39,26	11,82	39,21	11,99	39,16	12,16	39,10	12,33	39,05	12,50	41																
42	40,37	11,58	40,32	11,75	40,27	11,93	40,22	12,10	40,17	12,28	40,11	12,46	40,06	12,63	40,00	12,80	42																
43	41,33	11,85	41,28	12,03	41,23	12,21	41,18	12,40	41,12	12,57	41,07	12,75	41,01	12,93	40,95	13,11	43																
44	42,30	12,13	42,24	12,31	42,19	12,50	42,13	12,68	42,08	12,86	42,02	13,05	41,96	13,23	41,91	13,41	44																
45	43,26	12,40	43,20	12,59	43,15	12,78	43,09	12,97	43,03	13,15	42,98	13,34	42,92	13,53	42,86	13,72	45																
46	44,22	12,68	44,16	12,87	44,11	13,07	44,05	13,26	43,99	13,44	43,93	13,64	43,87	13,83	43,81	14,02	46																
47	45,18	12,96	45,12	13,15	45,07	13,35	45,01	13,55	44,95	13,74	44,89	13,94	44,83	14,13	44,76	14,33	47																
48	46,14	13,23	46,08	13,43	46,02	13,63	45,96	13,83	45,90	14,03	45,84	14,23	45,78	14,43	45,72	14,63	48																
49	47,10	13,51	47,04	13,71	46,98	13,92	46,92	14,12	46,86	14,33	46,80	14,53	46,73	14,74	46,67	14,94	49																
50	48,06	13,78	48,00	13,99	47,94	14,20	47,88	14,41	47,82	14,62	47,75	14,83	47,69	15,04	47,62	15,24	50																
51	49,02	14,06	48,96	14,27	48,90	14,49	48,84	14,70	48,77	14,91	48,71	15,12	48,64	15,34	48,57	15,55	51																
52	49,99	14,33	49,92	14,55	49,86	14,78	49,79	14,98	49,73	15,20																							

Distance	16 Degrees								17 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	58,64	16,81	58,56	17,07	58,49	17,33	58,41	17,58	58,33	17,83	58,26	18,09	58,18	18,34	58,10	18,60	61
62	59,60	17,09	59,52	17,35	59,45	17,61	59,37	17,87	59,29	18,13	59,21	18,39	59,13	18,64	59,05	18,90	62
63	60,56	17,36	60,48	17,63	60,41	17,89	60,33	18,16	60,25	18,42	60,17	18,68	60,08	18,95	60,00	19,21	63
64	61,52	17,64	61,44	17,91	61,36	18,18	61,28	18,45	61,20	18,71	61,12	18,98	61,04	19,25	60,95	19,51	64
65	62,48	17,92	62,40	18,19	62,32	18,46	62,24	18,73	62,16	19,00	62,08	19,27	61,99	19,55	61,91	19,82	65
66	63,44	18,19	63,36	18,47	63,28	18,75	63,20	19,02	63,12	19,30	63,03	19,57	62,95	19,85	62,86	20,12	66
67	64,40	18,47	64,32	18,75	64,24	19,03	64,16	19,31	64,07	19,59	63,99	19,87	63,90	20,15	63,81	20,43	67
68	65,37	18,74	65,28	19,03	65,20	19,31	65,11	19,60	65,03	19,88	64,94	20,16	64,85	20,45	64,76	20,73	68
69	66,33	19,02	66,24	19,31	66,16	19,60	66,07	19,89	65,99	20,17	65,90	20,46	65,81	20,75	65,72	21,04	69
70	67,29	19,30	67,20	19,59	67,12	19,88	67,03	20,17	66,94	20,47	66,85	20,76	66,76	21,05	66,69	21,34	70
71	68,25	19,57	68,16	19,87	68,08	20,17	67,99	20,46	67,90	20,76	67,81	21,05	67,71	21,35	67,62	21,65	71
72	69,21	19,85	69,12	20,15	69,04	20,45	68,95	20,75	68,85	21,05	68,76	21,35	68,67	21,65	68,57	21,95	72
73	70,17	20,12	70,08	20,43	69,99	20,73	69,90	21,04	69,81	21,34	69,72	21,65	69,62	21,95	69,53	22,26	73
74	71,13	20,40	71,04	20,71	70,95	21,02	70,86	21,33	70,77	21,64	70,67	21,94	70,58	22,25	70,48	22,56	74
75	72,09	20,67	72,00	20,99	71,91	21,30	71,82	21,62	71,72	21,93	71,63	22,24	71,53	22,55	71,43	22,86	75
76	73,06	20,95	72,96	21,27	72,87	21,59	72,78	21,90	72,68	22,22	72,58	22,54	72,48	22,85	72,38	23,17	76
77	74,02	21,22	73,92	21,55	73,83	21,87	73,73	22,19	73,64	22,51	73,54	22,83	73,44	23,16	73,34	23,48	77
78	74,98	21,50	74,88	21,83	74,79	22,15	74,69	22,48	74,59	22,81	74,49	23,13	74,39	23,46	74,29	23,78	78
79	75,94	21,78	75,84	22,11	75,75	22,44	75,65	22,77	75,55	23,10	75,45	23,43	75,34	23,76	75,24	24,08	79
80	76,90	22,05	76,80	22,39	76,71	22,72	76,61	23,06	76,50	23,39	76,40	23,72	76,30	24,06	76,19	24,39	80
81	77,86	22,33	77,76	22,67	77,67	23,01	77,56	23,34	77,46	23,68	77,36	24,02	77,25	24,36	77,14	24,69	81
82	78,82	22,60	78,72	22,95	78,62	23,29	78,52	23,62	78,42	23,98	78,31	24,32	78,21	24,66	78,10	25,00	82
83	79,78	22,88	79,68	23,23	79,58	23,57	79,48	23,92	79,37	24,27	79,27	24,61	79,16	24,96	79,05	25,30	83
84	80,75	23,15	80,64	23,51	80,54	23,86	80,44	24,21	80,33	24,56	80,22	24,91	80,11	25,26	80,00	25,61	84
85	81,71	23,43	81,60	23,79	81,50	24,14	81,40	24,50	81,29	24,88	81,18	25,21	81,07	25,56	80,95	25,91	85
86	82,67	23,71	82,56	24,07	82,46	24,43	82,35	24,79	82,24	25,14	82,13	25,50	82,02	25,86	81,91	26,22	86
87	83,63	23,98	83,52	24,35	83,42	24,71	83,31	25,07	83,20	25,44	83,09	25,80	82,97	26,16	82,86	26,52	87
88	84,59	24,26	84,48	24,63	84,38	24,99	84,27	25,36	84,15	25,73	84,04	26,10	83,93	26,46	83,81	26,83	88
89	85,55	24,53	85,44	24,91	85,34	25,28	85,22	25,65	85,11	26,02	85,00	26,39	84,88	26,76	84,76	27,13	89
90	86,51	24,81	86,41	25,19	86,29	25,56	86,18	25,94	86,07	26,31	85,95	26,69	85,84	27,06	85,72	27,44	90
91	87,47	25,08	87,37	25,47	87,25	25,85	87,14	26,23	87,02	26,61	86,91	26,99	86,79	27,36	86,67	27,74	91
92	88,44	25,36	88,33	25,75	88,21	26,13	88,10	26,51	87,98	26,90	87,86	27,28	87,74	27,67	87,62	28,05	92
93	89,40	25,64	89,29	26,03	89,17	26,41	89,05	26,80	88,94	27,19	88,82	27,58	88,70	27,97	88,57	28,35	93
94	90,36	25,91	90,25	26,30	90,13	26,70	90,01	27,09	89,89	27,48	89,77	27,88	89,65	28,27	89,53	28,66	94
95	91,32	26,19	91,21	26,58	91,09	26,98	90,97	27,38	90,85	27,76	90,73	28,17	90,60	28,57	90,48	28,96	95
96	92,28	26,46	92,17	26,86	92,05	27,27	91,93	27,67	91,81	28,07	91,68	28,47	91,56	28,87	91,43	29,27	96
97	93,24	26,74	93,13	27,14	93,01	27,55	92,88	27,96	92,76	28,36	92,64	28,76	92,51	29,17	92,38	29,57	97
98	94,20	27,01	94,09	27,42	93,97	27,83	93,84	28,24	93,72	28,65	93,59	29,06	93,47	29,47	93,34	29,88	98
99	95,16	27,29	95,05	27,70	94,92	28,12	94,80	28,53	94,67	28,94	94,55	29,36	94,42	29,77	94,29	30,18	99
100	96,13	27,56	96,01	27,98	95,88	28,40	95,76	28,82	95,63	29,24	95,50	29,65	95,37	30,07	95,24	30,49	100
101	97,09	27,84	96,97	28,26	96,84	28,69	96,72	29,10	96,59	29,53	96,46	29,95	96,33	30,37	96,19	30,79	101
102	98,05	28,12	97,93	28,54	97,80	28,97	97,67	29,40	97,54	29,82	97,41	30,25	97,28	30,67	97,15	31,10	102
103	99,01	28,39	98,89	28,82	98,76	29,25	98,63	29,69	98,50	30,11	98,37	30,54	98,23	30,97	98,10	31,40	103
104	99,97	28,67	99,85	29,10	99,72	29,54	99,59	29,97	99,46	30,41	99,32	30,84	99,19	31,27	99,05	31,71	104
105	100,9	28,94	100,8	29,38	100,7	29,82	100,5	30,26	100,4	30,70	100,3	31,14	100,1	31,58	100,0	32,01	105
106	101,9	29,22	101,8	29,66	101,6	30,11	101,5	30,55	101,4	30,99	101,2	31,43	101,1	31,88	100,0	32,32	106
107	102,9	29,49	102,7	29,94	102,6	30,39	102,5	30,84	102,3	31,28	102,2	31,73	102,0	32,18	101,9	32,62	107
108	103,8	29,77	103,7	30,22	103,6	30,67	10										

Distance	18 Degrees								19 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,95	0,31	0,95	0,31	0,95	0,32	0,95	0,32	0,95	0,33	0,94	0,33	0,94	0,33	0,94	0,34	1
2	1,90	0,62	1,90	0,63	1,90	0,63	1,89	0,64	1,89	0,65	1,89	0,66	1,88	0,67	1,88	0,68	2
3	2,85	0,93	2,85	0,94	2,84	0,95	2,84	0,96	2,84	0,98	2,83	0,99	2,83	1,00	2,82	1,01	3
4	3,80	1,24	3,80	1,25	3,79	1,27	3,79	1,29	3,78	1,30	3,78	1,32	3,77	1,33	3,76	1,35	4
5	4,75	1,54	4,75	1,57	4,74	1,59	4,73	1,61	4,73	1,63	4,72	1,65	4,71	1,67	4,71	1,69	5
6	5,71	1,85	5,70	1,88	5,69	1,90	5,68	1,93	5,67	1,95	5,66	1,98	5,66	2,00	5,65	2,03	6
7	6,66	2,16	6,65	2,19	6,64	2,22	6,63	2,25	6,62	2,28	6,61	2,31	6,60	2,34	6,59	2,36	7
8	7,61	2,47	7,60	2,50	7,59	2,54	7,57	2,57	7,56	2,60	7,55	2,64	7,54	2,67	7,53	2,70	8
9	8,56	2,78	8,55	2,82	8,53	2,86	8,52	2,89	8,51	2,93	8,50	2,97	8,48	3,00	8,47	3,04	9
10	9,51	3,09	9,50	3,13	9,48	3,17	9,47	3,21	9,46	3,26	9,44	3,30	9,43	3,34	9,41	3,38	10
11	10,46	3,40	10,45	3,44	10,43	3,49	10,42	3,54	10,40	3,58	10,38	3,63	10,37	3,67	10,35	3,72	11
12	11,41	3,71	11,40	3,76	11,38	3,81	11,36	3,86	11,35	3,91	11,33	3,96	11,31	4,01	11,29	4,06	12
13	12,36	4,02	12,35	4,07	12,33	4,12	12,31	4,18	12,29	4,23	12,27	4,29	12,25	4,34	12,24	4,39	13
14	13,31	4,33	13,30	4,38	13,28	4,44	13,26	4,50	13,24	4,56	13,22	4,62	13,20	4,67	13,18	4,73	14
15	14,27	4,63	14,24	4,70	14,22	4,76	14,20	4,82	14,18	4,88	14,16	4,95	14,14	5,01	14,12	5,07	15
16	15,22	4,94	15,19	5,01	15,17	5,08	15,15	5,14	15,13	5,21	15,11	5,27	15,08	5,34	15,06	5,41	16
17	16,17	5,25	16,14	5,32	16,12	5,39	16,10	5,46	16,07	5,53	16,05	5,60	16,02	5,67	16,00	5,74	17
18	17,12	5,56	17,09	5,64	17,07	5,71	17,04	5,79	17,02	5,86	16,99	5,93	16,97	6,01	16,94	6,08	18
19	18,07	5,87	18,04	5,95	18,02	6,03	17,99	6,11	17,97	6,19	17,94	6,26	17,91	6,34	17,88	6,42	19
20	19,02	6,18	18,99	6,26	18,97	6,3	18,94	6,43	18,91	6,51	18,88	6,59	18,85	6,68	18,82	6,76	20
21	19,97	6,49	19,94	6,58	19,91	6,66	19,89	6,71	19,86	6,84	19,83	6,92	19,80	7,01	19,76	7,10	21
22	20,92	6,80	20,89	6,89	20,86	6,98	20,83	7,07	20,80	7,16	20,77	7,25	20,74	7,34	20,71	7,43	22
23	21,87	7,11	21,84	7,20	21,81	7,30	21,78	7,39	21,75	7,49	21,71	7,58	21,68	7,68	21,65	7,77	23
24	22,82	7,42	22,79	7,52	22,76	7,61	22,73	7,71	22,69	7,81	22,66	7,91	22,62	8,01	22,59	8,11	24
25	23,78	7,72	23,74	7,83	23,71	7,93	23,67	8,04	23,64	8,14	23,60	8,24	23,57	8,34	23,53	8,45	25
26	24,73	8,03	24,69	8,14	24,66	8,25	24,62	8,37	24,58	8,46	24,55	8,57	24,51	8,68	24,47	8,79	26
27	25,68	8,34	25,64	8,45	25,60	8,57	25,57	8,68	25,53	8,79	25,49	8,90	25,45	9,01	25,41	9,12	27
28	26,63	8,65	26,59	8,77	26,55	8,88	26,51	9,00	26,47	9,12	26,43	9,23	26,39	9,35	26,35	9,46	28
29	27,58	8,96	27,54	9,08	27,50	9,20	27,46	9,32	27,42	9,44	27,38	9,56	27,34	9,68	27,29	9,80	29
30	28,53	9,27	28,49	9,39	28,45	9,52	28,41	9,64	28,37	9,77	28,32	9,89	28,28	10,01	28,23	10,14	30
31	29,48	9,58	29,44	9,71	29,40	9,84	29,35	9,96	29,31	10,09	29,27	10,22	29,22	10,35	29,18	10,48	31
32	30,43	9,89	30,39	10,02	30,35	10,15	30,30	10,29	30,26	10,42	30,21	10,55	30,16	10,68	30,12	10,81	32
33	31,38	10,20	31,34	10,33	31,29	10,47	31,25	10,61	31,20	10,74	31,15	10,88	31,11	11,01	31,06	11,15	33
34	32,34	10,51	32,30	10,65	32,24	10,79	32,19	10,93	32,15	11,07	32,10	11,21	32,05	11,35	32,00	11,49	34
35	33,29	10,82	33,25	10,96	33,19	11,11	33,14	11,25	33,09	11,39	33,04	11,54	32,99	11,68	32,94	11,83	35
36	34,24	11,12	34,20	11,27	34,14	11,42	34,09	11,57	34,04	11,72	33,99	11,87	33,93	12,02	33,88	12,17	36
37	35,19	11,43	35,15	11,59	35,09	11,74	35,04	11,89	34,98	12,05	34,93	12,20	34,88	12,35	34,82	12,50	37
38	36,14	11,74	36,10	11,90	36,04	12,06	35,98	12,21	35,93	12,37	35,88	12,53	35,82	12,68	35,76	12,84	38
39	37,09	12,05	37,05	12,21	36,98	12,37	36,93	12,54	36,88	12,70	36,82	12,86	36,76	13,02	36,71	13,18	39
40	38,04	12,36	37,99	12,53	37,93	12,69	37,88	12,86	37,82	13,02	37,76	13,19	37,71	13,35	37,65	13,52	40
41	38,99	12,67	38,94	12,84	38,88	13,01	38,81	13,18	38,77	13,34	38,71	13,52	38,65	13,69	38,59	13,85	41
42	39,94	12,98	39,89	13,15	39,83	13,33	39,77	13,50	39,71	13,67	39,65	13,85	39,59	14,02	39,53	14,19	42
43	40,89	13,29	40,84	13,46	40,78	13,64	40,72	13,82	40,66	14,00	40,60	14,18	40,53	14,35	40,47	14,53	43
44	41,85	13,60	41,79	13,78	41,73	13,96	41,66	14,14	41,60	14,32	41,54	14,51	41,48	14,69	41,41	14,87	44
45	42,80	13,91	42,74	14,09	42,67	14,28	42,61	14,47	42,55	14,65	42,47	14,84	42,42	15,02	42,35	15,21	45
46	43,75	14,21	43,69	14,40	43,62	14,60	43,56	14,79	43,49	14,98	43,43	15,17	43,36	15,35	43,29	15,54	46
47	44,70	14,52	44,63	14,72	44,57	14,91	44,51	15,11	44,44	15,30	44,37	15,50	44,30	15,69	44,23	15,88	47
48	45,65	14,83	45,58	15,03	45,52	15,23	45,45	15,43	45,39	15,63	45,32	15,82	45,25	16,02	45,18	16,22	48
49	46,60	15,14	46,53	15,34	46,47	15,55	46,40	15,75	46,33	15,9	46,26	16,15	46,19	16,36	46,12	16,56	49
50	47,55	15,4	47,48	15,66	47,42	15,86	47,35	16,07	47,28	16,28	47,21	16,48	47,13	16,69	47,06	16,90	50
51	48,50	15,76	48,43	15,97	48,36	16,18	48,29	16,39	48,22	16,60	48,15	16,81	48,07	17,02	48,00	17,23	51

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Distance	18 Degrees								19 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	58,01	18,85	57,94	19,10	57,85	19,35	57,76	19,61	57,68	19,86	57,59	20,11	57,50	20,36	57,41	20,61	61
62	58,97	19,16	58,89	19,42	58,80	19,67	58,71	19,93	58,62	20,18	58,53	20,44	58,44	20,70	58,35	20,95	62
63	59,92	19,47	59,84	19,73	59,74	19,99	59,66	20,25	59,57	20,51	59,48	20,77	59,39	21,03	59,29	21,29	63
64	60,87	19,78	60,79	20,04	60,69	20,31	60,60	20,57	60,51	20,84	60,42	21,10	60,33	21,36	60,24	21,63	64
65	61,82	20,09	61,74	20,36	61,64	20,62	61,55	20,89	61,46	21,16	61,36	21,43	61,27	21,70	61,18	21,96	65
66	62,77	20,39	62,69	20,67	62,59	20,94	62,50	21,21	62,40	21,49	62,31	21,76	62,21	22,03	62,12	22,30	66
67	63,72	20,70	63,64	20,98	63,54	21,26	63,44	21,54	63,35	21,81	63,25	22,09	63,16	22,37	63,06	22,64	67
68	64,67	21,01	64,59	21,29	64,49	21,58	64,39	21,86	64,29	22,14	64,20	22,42	64,10	22,70	64,00	22,98	68
69	65,62	21,32	65,54	21,61	65,43	21,89	65,34	22,18	65,24	22,46	65,14	22,75	65,04	23,03	64,94	23,32	69
70	66,57	21,63	66,48	21,12	66,38	22,21	66,28	22,50	66,19	22,79	66,09	23,08	65,98	23,37	65,88	23,65	70
71	67,52	21,94	67,43	22,23	67,33	22,53	67,23	22,82	67,13	23,11	67,03	23,41	66,93	23,70	66,82	23,99	71
72	68,48	22,25	68,38	22,55	68,28	22,85	68,18	23,14	68,07	23,44	67,97	23,74	67,87	24,03	67,76	24,33	72
73	69,43	22,56	69,33	22,86	69,23	23,16	69,13	23,47	69,02	23,76	68,92	24,07	68,81	24,37	68,71	24,67	73
74	70,38	22,87	70,28	23,17	70,18	23,48	70,07	23,79	69,97	24,09	69,86	24,40	69,76	24,70	69,65	25,01	74
75	71,33	23,18	71,23	23,49	71,12	23,80	71,02	24,11	70,91	24,42	70,81	24,73	70,70	25,04	70,59	25,34	75
76	72,28	23,48	72,18	23,80	72,07	24,11	71,97	24,43	71,86	24,74	71,75	25,06	71,64	25,37	71,53	25,68	76
77	73,23	23,79	73,13	24,11	73,02	24,43	72,91	24,75	72,80	25,07	72,69	25,39	72,58	25,70	72,47	26,02	77
78	74,18	24,10	74,08	24,43	73,97	24,75	73,86	25,07	73,75	25,39	73,64	25,72	73,53	26,04	73,41	26,36	78
79	75,13	24,41	75,03	24,74	74,92	25,07	74,81	25,39	74,69	25,72	74,58	26,05	74,47	26,37	74,35	26,70	79
80	76,08	24,72	75,98	25,05	75,87	25,38	75,75	25,71	75,64	26,04	75,53	26,37	75,41	26,70	75,29	27,03	80
81	77,04	25,03	76,92	25,37	76,81	25,70	76,70	26,04	76,59	26,37	76,47	26,70	76,35	27,04	76,23	27,37	81
82	77,99	25,34	77,87	25,68	77,76	26,02	77,65	26,36	77,53	26,70	77,41	27,03	77,30	27,37	77,18	27,71	82
83	78,94	25,65	78,82	25,99	78,71	26,34	78,59	26,68	78,48	27,02	78,36	27,36	78,24	27,71	78,12	28,05	83
84	79,89	25,96	79,77	26,31	79,66	26,65	79,54	27,00	79,42	27,35	79,30	27,69	79,18	28,04	79,06	28,39	84
85	80,84	26,27	80,72	26,62	80,61	26,91	80,49	27,32	80,37	27,67	80,25	28,02	80,12	28,37	80,00	28,72	85
86	81,79	26,58	81,67	26,93	81,56	27,29	81,44	27,64	81,31	28,00	81,19	28,35	81,07	28,71	80,94	29,06	86
87	82,74	26,88	82,62	27,24	82,50	27,60	82,38	27,97	82,26	28,32	82,14	28,68	82,01	29,04	81,88	29,40	87
88	83,69	27,19	83,57	27,56	83,45	27,92	83,33	28,29	83,21	28,65	83,08	29,01	82,95	29,37	82,82	29,74	88
89	84,64	27,50	84,52	27,87	84,40	28,24	84,28	28,61	84,15	28,98	84,02	29,34	83,89	29,71	83,76	30,07	89
90	85,59	27,81	85,47	28,18	85,35	28,56	85,22	28,93	85,10	29,30	84,97	29,67	84,84	30,04	84,71	30,41	90
91	86,55	28,12	86,42	28,50	86,30	28,87	86,17	29,25	86,04	29,63	85,91	30,00	85,78	30,38	85,65	30,75	91
92	87,50	28,43	87,37	28,81	87,25	29,19	87,12	29,57	86,99	29,95	86,86	30,33	86,72	30,71	86,59	31,09	92
93	88,45	28,74	88,32	29,12	88,19	29,51	88,06	29,89	87,93	30,28	87,80	30,66	87,67	31,04	87,53	31,43	93
94	89,40	29,05	89,27	29,44	89,14	29,89	89,01	30,22	88,88	30,60	88,74	30,99	88,61	31,38	88,49	31,76	94
95	90,35	29,36	90,22	29,75	90,09	30,14	89,96	30,54	89,82	30,93	89,69	31,32	89,55	31,71	89,41	32,10	95
96	91,30	29,67	91,17	30,06	91,04	30,46	90,91	30,86	90,77	31,25	90,63	31,65	90,49	32,05	90,35	32,44	96
97	92,25	29,97	92,12	30,38	91,99	30,78	91,85	31,18	91,71	31,58	91,58	31,98	91,44	32,38	91,29	32,78	97
98	93,20	30,28	93,07	30,69	92,93	31,09	92,80	31,50	92,66	31,90	92,52	32,31	92,38	32,71	92,24	33,12	98
99	94,15	30,59	94,02	31,00	93,88	31,41	93,75	31,82	93,61	32,23	93,46	32,64	93,32	33,05	93,18	33,45	99
100	95,11	30,90	94,97	31,32	94,83	31,71	94,69	32,14	94,55	32,56	94,41	32,97	94,26	33,38	94,12	33,79	100
101	96,06	31,21	95,92	31,63	95,78	32,05	95,64	32,46	95,50	32,88	95,35	33,30	95,21	33,71	95,06	34,13	101
102	97,01	31,52	96,87	31,94	96,73	32,36	96,59	32,79	96,44	33,21	96,30	33,63	96,15	34,05	96,00	34,49	102
103	97,96	31,83	97,82	32,25	97,68	32,68	97,53	33,11	97,39	33,53	97,24	33,96	97,09	34,38	96,94	34,81	103
104	98,91	32,14	98,78	32,57	98,62	33,00	98,48	33,43	98,33	33,86	98,18	34,29	98,03	34,72	97,88	35,14	104
105	99,86	32,45	99,73	32,88	99,57	33,32	99,43	33,75	99,28	34,18	99,13	34,62	98,98	35,05	98,82	35,48	105
106	100,8	32,76	100,7	33,19	100,5	33,63	100,4	34,07	100,2	34,51	100,1	34,95	99,92	35,38	99,80	35,82	106
107	101,8	33,06	101,6	33,51	101,5	33,95	101,3	34,39	101,2	34,83	101,0	35,28	100,9	35,72	100,7	36,16	107
108	102,7	33,37	102,6	33,88	102,4	34,27	102,3	34,72	102,1	35,16	102,0	35,61	101,8	36,05	101,7	36,49	108
109	103,7	33,68	103,5	34,13	103,4	34,59	103,2	35,04	103,1	35,48	102,9	35,94	102,7	36,38	102,6	36,83	109
110	104,6	33,99	104,5	34,45	104,3	34,90	104,2	35,36	104,0	35,81	103,9	36,27	103,7	36,72	103,6	37,17	110
111	105,6	34,30	105,4	34,76	105,3	35,22	105,1	35,68	105,0	36,14	104,8	36,60	104,6	37,05	104,5	37,51	111
112	106,5	34,61	106,4	35,07	106,2	35,54	106,1	36,00	105,9	36,46	105,7	36,93	105,6	37,39	105,5	37,85	112
113	107,5	34,92	107,3	35,39	107,2	35,85	107,0	36,22	106,8	36,79	106,7	37,26	106,5	37,72	106,4	38,18	113
114	108,4	35,23	108,3	35,70	108,1	36,17	108,0	36,64	107,8	37,11	107,6	37,58	107,5	38,05	107,3	38,52	114
115	109,4	35,54	109,2	36,01	109,1	36,49	109,9	36,97	108,7	37,44	108,6	37,91	108,4	38,39	108,3	38,86	115
116	110,3	35,85	110,2	36,33	110,0	36,81	109,8	37,29	109,7	37,76	109,5	38,24	109,3	38,72	109,2	39,20	116
117	111,3	36,16	111,1	36,64	111,0	37,12	110,8	37,61	110,6	38,09	110,5	38,57	110,3	39,06	110,2	39,54	117
118	112,2	36,46	112,1	36,95	112,9	37,44	111,7	37,91	111,6	38,42	111,4	38,90	111,2	39,39	111,1	39,87	118
119	113,2	36,77	113,0	37,27	113,9	37,76	112,7	38,25	112,5	38,74	112,3	39,23	112,2	39,72	112,0	40,21	119
120	114,1	37,10	114,0	37,58	114,8	38,08	113,6	38,57	113,5	39,07	113,3	39,56	113,1	40,06	113,0	40,55	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	72 Deg.				71 Degrees				70 Degrees								

Distance	20 Degrees								21 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,94	0,34	0,94	0,35	0,94	0,35	0,94	0,35	0,93	0,36	0,93	0,36	0,93	0,37	0,93	0,37	1
2	1,88	0,68	1,88	0,69	1,87	0,70	1,87	0,71	1,87	0,72	1,86	0,73	1,86	0,73	1,86	0,74	2
3	2,82	1,03	2,82	1,04	2,81	1,05	2,81	1,06	2,80	1,08	2,80	1,09	2,79	1,10	2,79	1,11	3
4	3,76	1,37	3,75	1,38	3,75	1,40	3,74	1,42	3,73	1,43	3,73	1,45	3,72	1,47	3,72	1,49	4
5	4,70	1,71	4,69	1,73	4,68	1,75	4,68	1,77	4,67	1,79	4,66	1,81	4,65	1,83	4,64	1,85	5
6	5,64	2,05	5,63	2,08	5,62	2,10	5,61	2,13	5,60	2,15	5,59	2,18	5,58	2,20	5,57	2,22	6
7	6,58	2,39	6,57	2,42	6,56	2,45	6,55	2,48	6,54	2,51	6,52	2,54	6,51	2,57	6,50	2,59	7
8	7,52	2,74	7,51	2,77	7,49	2,80	7,48	2,83	7,47	2,87	7,46	2,90	7,44	2,93	7,43	2,96	8
9	8,46	3,08	8,44	3,12	8,43	3,15	8,42	3,19	8,40	3,23	8,39	3,26	8,37	3,30	8,36	3,34	9
10	9,40	3,42	9,38	3,46	9,37	3,50	9,35	3,54	9,34	3,58	9,32	3,62	9,30	3,67	9,29	3,71	10
11	10,34	3,76	10,32	3,81	10,30	3,85	10,29	3,90	10,27	3,94	10,25	3,99	10,23	4,03	10,22	4,08	11
12	11,28	4,10	11,26	4,15	11,24	4,20	11,22	4,25	11,20	4,30	11,18	4,35	11,17	4,40	11,15	4,45	12
13	12,22	4,45	12,20	4,50	12,18	4,55	12,16	4,61	12,14	4,66	12,12	4,71	12,10	4,77	12,07	4,82	13
14	13,16	4,79	13,14	4,85	13,11	4,90	13,09	4,96	13,07	5,02	13,05	5,07	13,03	5,13	13,00	5,19	14
15	14,10	5,13	14,07	5,19	14,05	5,25	14,03	5,31	14,00	5,38	13,98	5,44	13,96	5,50	13,93	5,56	15
16	15,04	5,47	15,01	5,54	14,99	5,60	14,96	5,67	14,94	5,73	14,91	5,80	14,89	5,86	14,86	5,93	16
17	15,98	5,81	15,95	5,88	15,92	5,95	15,90	6,02	15,87	6,09	15,84	6,16	15,82	6,23	15,79	6,30	17
18	16,92	6,16	16,89	6,23	16,86	6,30	16,83	6,38	16,80	6,45	16,78	6,52	16,75	6,60	16,72	6,67	18
19	17,85	6,50	17,83	6,58	17,80	6,65	17,77	6,73	17,74	6,81	17,71	6,89	17,68	6,96	17,65	7,04	19
20	18,79	6,84	18,76	6,92	18,73	7,00	18,70	7,09	18,67	7,17	18,64	7,25	18,61	7,33	18,58	7,41	20
21	19,73	7,18	19,71	7,27	19,67	7,35	19,64	7,44	19,61	7,53	19,57	7,61	19,54	7,70	19,51	7,78	21
22	20,67	7,52	20,64	7,61	20,61	7,71	20,57	7,80	20,54	7,88	20,50	7,97	20,47	8,06	20,43	8,15	22
23	21,61	7,87	21,58	7,96	21,54	8,06	21,51	8,15	21,47	8,24	21,44	8,34	21,40	8,43	21,36	8,52	23
24	22,55	8,21	22,52	8,31	22,48	8,41	22,45	8,50	22,41	8,60	22,37	8,70	22,33	8,80	22,29	8,89	24
25	23,49	8,55	23,46	8,65	23,42	8,76	23,38	8,86	23,34	8,96	23,30	9,06	23,26	9,16	23,22	9,26	25
26	24,43	8,89	24,39	9,00	24,35	9,11	24,31	9,21	24,27	9,32	24,23	9,42	24,19	9,53	24,15	9,63	26
27	25,37	9,23	25,33	9,35	25,29	9,46	25,25	9,57	25,21	9,68	25,16	9,79	25,12	9,90	25,08	10,00	27
28	26,31	9,58	26,27	9,69	26,23	9,81	26,18	9,92	26,14	10,03	26,10	10,15	26,05	10,26	26,01	10,38	28
29	27,25	9,92	27,21	10,04	27,16	10,16	27,12	10,27	27,07	10,39	27,03	10,51	26,98	10,63	26,94	10,75	29
30	28,19	10,26	28,15	10,38	28,10	10,51	28,05	10,63	28,01	10,75	27,96	10,87	27,91	11,00	27,86	11,12	30
31	29,13	10,60	29,08	10,73	29,04	10,86	28,99	10,98	28,94	11,11	28,89	11,24	28,84	11,36	28,79	11,49	31
32	30,07	10,95	30,02	11,08	29,97	11,21	29,93	11,34	29,87	11,47	29,82	11,60	29,77	11,73	29,72	11,86	32
33	31,01	11,29	30,96	11,42	30,91	11,56	30,86	11,69	30,81	11,83	30,76	11,96	30,70	12,10	30,65	12,23	33
34	31,95	11,63	31,90	11,77	31,85	11,91	31,80	12,05	31,74	12,18	31,69	12,32	31,64	12,46	31,58	12,60	34
35	32,89	11,97	32,84	12,12	32,78	12,26	32,73	12,40	32,68	12,54	32,62	12,69	32,57	12,83	32,51	12,97	35
36	33,83	12,31	33,78	12,46	33,72	12,61	33,67	12,76	33,61	12,90	33,55	13,05	33,50	13,19	33,44	13,34	36
37	34,77	12,66	34,71	12,81	34,66	12,96	34,60	13,11	34,54	13,26	34,48	13,41	34,43	13,56	34,37	13,71	37
38	35,71	13,00	35,62	13,15	35,59	13,31	35,54	13,46	35,48	13,62	35,41	13,77	35,36	13,93	35,29	14,08	38
39	36,65	13,34	36,59	13,50	36,53	13,66	36,47	13,82	36,41	13,98	36,35	14,14	36,29	14,29	36,22	14,45	39
40	37,59	13,68	37,53	13,85	37,47	14,01	37,41	14,17	37,34	14,36	37,28	14,50	37,22	14,66	37,15	14,82	40
41	38,53	14,02	38,47	14,19	38,40	14,36	38,34	14,53	38,28	14,69	38,21	14,86	38,15	15,03	38,08	15,19	41
42	39,47	14,37	39,40	14,54	39,34	14,71	39,28	14,88	39,21	15,05	39,14	15,22	39,08	15,39	39,01	15,56	42
43	40,41	14,71	40,34	14,88	40,28	15,06	40,21	15,23	40,14	15,41	40,08	15,59	40,01	15,76	39,94	15,93	43
44	41,35	15,05	41,28	15,23	41,21	15,41	41,15	15,59	41,08	15,77	41,01	15,95	40,94	16,13	40,87	16,30	44
45	42,29	15,39	42,22	15,58	42,15	15,76	42,08	15,94	42,01	16,13	41,94	16,31	41,87	16,49	41,80	16,67	45
46	43,23	15,73	43,16	15,92	43,09	16,11	43,02	16,30	42,94	16,49	42,87	16,67	42,80	16,86	42,73	17,05	46
47	44,17	16,08	44,10	16,27	44,02	16,46	43,95	16,65	43,88	16,84	43,80	17,04	43,73	17,23	43,65	17,42	47
48	45,11	16,42	45,03	16,61	44,96	16,81	44,89	17,01	44,81	17,20	44,74	17,40	44,66	17,59	44,58	17,79	48
49	46,05	16,76	45,97	16,96	45,90	17,16	45,82	17,36	45,75	17,56	45,67	17,76	45,59	17,96	45,51	18,16	49
50	46,99	17,10	46,91	17,31	46,83	17,51	46,76	17,72	46,68	17,92	46,60	18,12	46,52	18,33	46,44	18,53	50
51	47,93	17,44	47,85	17,65	47,77	17,86	47,69	18,07	47,61	18,28	47,53	18,49	47,45	18,69	47,37	18,90	51
52	48,86	17,79	48,79	18,00	48,71	18,21	48,63	18,42	48,54	18,64	48,47	18,85	48,38				

TRAVERSE TABLE, 712.

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Distance	20 Degrees								21 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	57,32	20,86	57,23	21,11	57,14	21,36	57,04	21,61	56,95	21,86	56,85	22,11	56,76	22,36	56,66	22,60	61
62	58,26	21,21	58,17	21,46	58,07	21,71	57,98	21,97	57,88	22,22	57,79	22,47	57,69	22,73	57,59	22,98	62
63	59,20	21,55	59,11	21,81	59,01	22,06	58,91	22,32	58,82	22,58	58,72	22,83	58,62	23,09	58,52	23,35	63
64	60,14	21,89	60,04	22,15	59,95	22,41	59,85	22,67	59,75	22,94	59,65	23,20	59,55	23,46	59,44	23,72	64
65	61,08	22,23	60,98	22,50	60,88	22,76	60,79	23,03	60,68	23,29	60,58	23,56	60,48	23,82	60,37	24,09	65
66	62,02	22,57	61,92	22,84	61,82	23,11	61,72	23,38	61,62	23,65	61,51	23,92	61,41	24,19	61,30	24,46	66
67	62,96	22,92	62,86	23,19	62,76	23,46	62,66	23,74	62,55	24,01	62,45	24,28	62,34	24,56	62,23	24,83	67
68	63,90	23,26	63,80	23,54	63,69	23,82	63,59	24,09	63,48	24,37	63,38	24,65	63,27	24,92	63,16	25,20	68
69	64,84	23,60	64,74	23,88	64,63	24,17	64,53	24,44	64,42	24,73	64,31	25,01	64,20	25,29	64,09	25,57	69
70	65,78	23,94	65,67	24,23	65,57	24,52	65,46	24,80	65,35	25,09	65,24	25,37	65,13	25,66	65,02	25,94	70
71	66,72	24,28	66,61	24,57	66,50	24,87	66,40	25,15	66,28	25,44	66,17	25,73	66,06	26,02	65,95	26,31	71
72	67,66	24,63	67,55	24,92	67,44	25,22	67,33	25,51	67,22	25,80	67,11	26,10	66,99	26,39	66,88	26,68	72
73	68,60	24,97	68,49	25,27	68,38	25,57	68,27	25,86	68,15	26,16	68,04	26,46	67,92	26,76	67,80	27,05	73
74	69,54	25,31	69,43	25,61	69,31	25,92	69,20	26,22	69,09	26,52	68,97	26,82	68,85	27,12	68,73	27,42	74
75	70,48	25,65	70,36	25,96	70,25	26,27	70,14	26,57	70,02	26,88	69,90	27,18	69,78	27,49	69,66	27,79	75
76	71,42	25,99	71,30	26,31	71,19	26,62	71,07	26,93	70,95	27,24	70,83	27,55	70,71	27,85	70,59	28,16	76
77	72,36	26,34	72,24	26,65	72,12	26,97	72,01	27,28	71,89	27,59	71,77	27,91	71,64	28,22	71,52	28,52	77
78	73,30	26,68	73,18	27,00	73,06	27,31	72,94	27,63	72,82	27,95	72,70	28,27	72,57	28,59	72,45	28,90	78
79	74,24	27,02	74,12	27,34	74,00	27,67	73,88	27,99	73,75	28,31	73,63	28,62	73,50	28,95	73,38	29,27	79
80	75,18	27,36	75,06	27,69	74,93	28,02	74,81	28,34	74,69	28,67	74,56	29,00	74,43	29,32	74,31	29,65	80
81	76,12	27,70	75,99	28,04	75,87	28,37	75,75	28,70	75,62	29,03	75,49	29,36	75,37	29,69	75,23	30,02	81
82	77,05	28,05	76,93	28,38	76,81	28,72	76,68	29,05	76,55	29,39	76,43	29,72	76,30	30,05	76,16	30,39	82
83	77,99	28,39	77,87	28,73	77,74	29,07	77,62	29,41	77,49	29,75	77,36	30,08	77,23	30,42	77,09	30,76	83
84	78,93	28,73	78,81	29,07	78,68	29,42	78,55	29,76	78,42	30,10	78,29	30,45	78,16	30,79	78,02	31,13	84
85	79,87	29,07	79,75	29,42	79,62	29,77	79,49	30,11	79,35	30,46	79,22	30,81	79,09	31,15	78,95	31,50	85
86	80,81	29,41	80,68	29,77	80,55	30,12	80,42	30,47	80,29	30,82	80,15	31,17	80,02	31,52	79,88	31,87	86
87	81,75	29,76	81,62	30,11	81,49	30,47	81,36	30,82	81,22	31,16	81,09	31,53	80,95	31,89	80,81	32,24	87
88	82,69	30,10	82,56	30,46	82,43	30,82	82,29	31,18	82,15	31,54	82,02	31,89	81,88	32,25	81,74	32,61	88
89	83,63	30,44	83,50	30,81	83,36	31,17	83,23	31,53	83,09	31,90	82,95	32,26	82,81	32,62	82,66	32,98	89
90	84,57	30,78	84,44	31,15	84,30	31,54	84,16	31,89	84,02	32,25	83,88	32,62	83,74	32,99	83,59	33,35	90
91	85,51	31,12	85,38	31,50	85,24	31,87	85,10	32,24	84,96	32,61	84,81	32,98	84,67	33,35	84,52	33,72	91
92	86,45	31,47	86,31	31,84	86,17	32,23	86,03	32,60	85,89	32,97	85,75	33,35	85,60	33,72	85,45	34,09	92
93	87,39	31,81	87,25	32,19	87,11	32,57	86,97	32,95	86,82	33,33	86,68	33,71	86,53	34,09	86,38	34,46	93
94	88,33	32,15	88,19	32,54	88,05	32,92	87,90	33,30	87,76	33,69	87,61	34,07	87,46	34,45	87,31	34,83	94
95	89,27	32,49	89,13	32,88	88,98	33,27	88,84	33,66	88,69	34,04	88,54	34,43	88,39	34,82	88,24	35,20	95
96	90,21	32,83	90,07	33,23	89,92	33,62	89,77	34,01	89,62	34,40	89,47	34,80	89,32	35,18	89,17	35,57	96
97	91,15	33,18	91,00	33,57	90,86	33,97	90,71	34,37	90,56	34,76	90,41	35,16	90,25	35,55	90,10	35,94	97
98	92,09	33,52	91,94	33,92	91,79	34,32	91,64	34,72	91,49	35,11	91,34	35,52	91,18	35,92	91,02	36,31	98
99	93,03	33,86	92,88	34,27	92,73	34,67	92,58	35,07	92,42	35,48	92,27	35,88	92,11	36,28	91,95	36,69	99
100	93,97	34,20	93,82	34,61	93,67	35,02	93,51	35,43	93,36	35,84	93,20	36,22	93,04	36,65	92,88	37,06	100
101	94,91	34,54	94,76	34,96	94,60	35,37	94,45	35,78	94,29	36,20	94,13	36,61	93,97	37,02	93,81	37,43	101
102	95,85	34,89	95,70	35,30	95,54	35,72	95,39	36,14	95,23	36,55	95,06	36,97	94,90	37,38	94,74	37,80	102
103	96,79	35,23	96,63	35,65	96,48	36,07	96,32	36,49	96,16	36,92	96,00	37,33	95,83	37,75	95,67	38,17	103
104	97,73	35,57	97,57	36,00	97,41	36,42	97,26	36,85	97,09	37,27	96,93	37,70	96,76	38,12	96,60	38,54	104
105	98,67	35,91	98,51	36,34	98,35	36,77	98,19	37,20	98,03	37,63	97,86	38,06	97,69	38,48	97,53	38,91	105
106	99,61	36,25	99,45	36,69	99,29	37,12	99,12	37,56	98,96	37,99	98,79	38,42	98,63	38,85	98,45	39,28	106
107	100,55	36,60	100,40	37,04	100,24	37,47	100,08	37,91	99,92	38,35	99,73	38,78	99,56	39,22	99,38	39,65</	

TRAVERSE TABLE, 712.

22 Degrees

23 Degrees

Distance	22 Degrees								23 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,93	0,38	0,93	0,38	0,92	0,38	0,92	0,39	0,92	0,39	0,92	0,40	0,92	0,40	0,92	0,40	1
2	1,85	0,75	1,85	0,75	1,85	0,77	1,84	0,77	1,84	0,78	1,84	0,79	1,83	0,80	1,83	0,81	2
3	2,78	1,12	2,78	1,14	2,77	1,15	2,77	1,16	2,76	1,17	2,76	1,18	2,75	1,20	2,75	1,21	3
4	3,71	1,50	3,70	1,52	3,70	1,53	3,69	1,55	3,68	1,56	3,68	1,58	3,67	1,60	3,66	1,61	4
5	4,64	1,87	4,63	1,89	4,62	1,91	4,61	1,93	4,60	1,95	4,59	1,97	4,59	1,99	4,58	2,01	5
6	5,55	2,25	5,55	2,27	5,54	2,30	5,53	2,32	5,52	2,34	5,51	2,37	5,50	2,39	5,49	2,42	6
7	6,49	2,62	6,48	2,65	6,47	2,68	6,46	2,71	6,44	2,74	6,43	2,76	6,42	2,79	6,41	2,82	7
8	7,42	3,00	7,40	3,03	7,39	3,06	7,38	3,09	7,36	3,13	7,35	3,16	7,34	3,19	7,32	3,22	8
9	8,35	3,37	8,33	3,41	8,32	3,44	8,30	3,48	8,29	3,52	8,27	3,55	8,25	3,59	8,24	3,63	9
10	9,27	3,75	9,26	3,79	9,24	3,83	9,22	3,87	9,21	3,91	9,19	3,95	9,17	3,99	9,15	4,03	10
11	10,20	4,12	10,18	4,17	10,16	4,21	10,14	4,25	10,13	4,30	10,11	4,34	10,09	4,39	10,07	4,43	11
12	11,13	4,50	11,11	4,54	11,09	4,59	11,07	4,64	11,05	4,70	11,03	4,74	11,01	4,79	10,98	4,83	12
13	12,05	4,87	12,03	4,92	12,01	4,97	11,99	5,03	11,97	5,08	11,94	5,13	11,92	5,18	11,90	5,24	13
14	12,98	5,24	12,96	5,30	12,94	5,36	12,91	5,41	12,89	5,47	12,86	5,53	12,84	5,58	12,81	5,64	14
15	13,91	5,62	13,88	5,68	13,86	5,74	13,83	5,80	13,81	5,86	13,78	5,92	13,76	5,98	13,73	6,04	15
16	14,84	5,99	14,81	6,06	14,78	6,12	14,76	6,19	14,73	6,25	14,70	6,32	14,67	6,38	14,65	6,44	16
17	15,76	6,37	15,73	6,44	15,71	6,51	15,68	6,57	15,65	6,64	15,62	6,71	15,59	6,78	15,56	6,85	17
18	16,69	6,74	16,66	6,82	16,63	6,89	16,60	6,96	16,57	7,03	16,54	7,11	16,51	7,18	16,48	7,2	18
19	17,62	7,12	17,59	7,19	17,55	7,27	17,52	7,35	17,49	7,42	17,46	7,50	17,42	7,58	17,39	7,65	19
20	18,54	7,49	18,51	7,57	18,48	7,65	18,44	7,73	18,41	7,82	18,38	7,90	18,34	7,98	18,31	8,06	20
21	19,47	7,87	19,44	7,95	19,40	8,04	19,37	8,12	19,33	8,21	19,30	8,29	19,26	8,37	19,22	8,46	21
22	20,40	8,24	20,36	8,33	20,33	8,42	20,29	8,51	20,25	8,60	20,21	8,69	20,18	8,77	20,14	8,86	22
23	21,33	8,62	21,29	8,71	21,25	8,80	21,21	8,89	21,17	8,99	21,13	9,08	21,09	9,17	21,05	9,26	23
24	22,25	8,99	22,21	9,09	22,17	9,18	22,13	9,28	22,09	9,38	22,05	9,47	22,01	9,57	21,97	9,66	24
25	23,18	9,37	23,14	9,47	23,10	9,57	23,07	9,67	23,03	9,77	22,97	9,87	22,93	9,97	22,88	10,07	25
26	24,11	9,74	24,06	9,84	24,02	9,95	23,98	10,05	23,93	10,16	23,89	10,26	23,84	10,37	23,80	10,47	26
27	25,03	10,11	24,99	10,22	24,95	10,33	24,90	10,44	24,85	10,55	24,81	10,66	24,76	10,77	24,71	10,87	27
28	25,96	10,49	25,9	10,60	25,87	10,72	25,82	10,83	25,77	10,94	25,73	11,05	25,68	11,16	25,63	11,28	28
29	26,89	10,86	26,84	10,98	26,79	11,10	26,74	11,21	26,70	11,33	26,65	11,45	26,60	11,56	26,54	11,68	29
30	27,82	11,24	27,77	11,36	27,72	11,48	27,67	11,60	27,62	11,72	27,56	11,84	27,51	11,96	27,46	12,08	30
31	28,74	11,61	28,69	11,74	28,64	11,86	28,59	11,99	28,54	12,11	28,48	12,24	28,43	12,36	28,37	12,49	31
32	29,67	11,99	29,62	12,11	29,56	12,25	29,51	12,38	29,46	12,50	29,40	12,63	29,35	12,76	29,29	12,89	32
33	30,60	12,36	30,54	12,50	30,49	12,63	30,43	12,76	30,38	12,89	30,32	13,03	30,26	13,16	30,21	13,29	33
34	31,52	12,74	31,47	12,87	31,41	13,01	31,36	13,15	31,30	13,28	31,24	13,42	31,18	13,56	31,12	13,69	34
35	32,45	13,11	32,39	13,25	32,34	13,39	32,28	13,54	32,22	13,68	32,16	13,82	32,10	13,96	32,04	14,10	35
36	33,38	13,49	33,32	13,63	33,26	13,78	33,20	13,92	33,14	14,07	33,08	14,21	33,01	14,36	32,95	14,5	36
37	34,31	13,86	34,25	14,01	34,18	14,16	34,12	14,31	34,06	14,46	34,00	14,61	33,93	14,75	33,87	14,90	37
38	35,23	14,24	35,17	14,39	35,11	14,54	35,04	14,69	34,98	14,85	34,91	15,00	34,85	15,15	34,78	15,30	38
39	36,16	14,61	36,10	14,77	36,03	14,92	35,97	15,08	35,90	15,24	35,83	15,40	35,77	15,55	35,70	15,71	39
40	37,09	14,98	37,02	15,1	36,96	15,30	36,89	15,47	36,82	15,63	36,75	15,79	36,68	15,95	36,61	16,11	40
41	38,01	15,36	37,95	15,52	37,88	15,69	37,81	15,86	37,74	16,02	37,67	16,19	37,60	16,35	37,53	16,51	41
42	38,94	15,73	38,87	15,90	38,80	16,07	38,73	16,24	38,66	16,41	38,59	16,59	38,52	16,75	38,44	16,92	42
43	39,87	16,10	39,80	16,28	39,73	16,45	39,66	16,63	39,58	16,80	39,51	16,97	39,43	17,15	39,36	17,32	43
44	40,80	16,48	40,72	16,66	40,65	16,84	40,58	17,02	40,50	17,19	40,43	17,37	40,35	17,54	40,27	17,72	44
45	41,72	16,85	41,65	17,04	41,57	17,22	41,50	17,40	41,42	17,58	41,35	17,76	41,27	17,94	41,19	18,12	45
46	42,65	17,23	42,58	17,42	42,50	17,60	42,42	17,79	42,34	17,97	42,27	18,16	42,18	18,34	42,10	18,53	46
47	43,58	17,61	43,50	17,80	43,42	17,99	43,34	18,18	43,26	18,36	43,18	18,55	43,10	18,74	43,02	18,93	47
48	44,51	17,98	44,43	18,18	44,35	18,37	44,27	18,56	44,18	18,76	44,10	18,95	44,02	19,14	43,93	19,33	48
49	45,43	18,36	45,35	18,55	45,27	18,75	45,19	18,95	45,11	19,15	45,02	19,34	44,94	19,54	44,85	19,73	49
50	46,36	18,73	46,28	18,93	46,19	19,13	46,11	19,34	46,03	19,54	45,94	19,74	45,85	19,94	45,77	20,14	50
51	47,29	19,11	47,20	19,31	47,12	19,52	47,03	19,72	46,95	19,93	46,86	20,13	46,77	20,34	46,68	20,54	51
52	48,21	19,48	48,13	19,69	48,04	19,90	47,95	20,11	47,87	20,32	47,78	20,53	47,69	20,74	47,60	20,94	52
53																	

66 Degrees

TRAVERSE TABLE, 712

331

Distance	22 Degrees								23 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	6,56	22,85	56,46	23,10	56,36	23,34	56,25	23,59	56,15	23,83	56,05	24,08	55,94	24,32	55,83	24,57	61
62	57,49	23,23	57,38	23,48	57,28	23,73	57,18	23,98	57,07	24,22	56,97	24,47	56,86	24,72	56,75	24,97	62
63	58,41	23,60	58,31	23,86	58,21	24,11	58,10	24,37	57,99	24,62	57,88	24,87	57,78	25,12	57,66	25,37	63
64	59,34	23,98	59,23	24,23	59,13	24,49	59,02	24,75	58,91	25,01	58,80	25,26	58,69	25,52	58,58	25,78	64
65	60,27	24,35	60,16	24,61	60,05	24,87	59,94	25,14	59,83	25,40	59,72	25,66	59,61	25,92	59,49	26,18	65
66	61,19	24,72	61,08	24,99	60,98	25,26	60,87	25,52	60,75	25,79	60,64	26,05	60,53	26,32	60,41	26,58	66
67	62,12	25,10	62,01	25,37	61,90	25,63	61,79	25,91	61,67	26,18	61,56	26,45	61,44	26,72	61,32	26,99	67
68	63,05	25,47	62,94	25,75	62,82	26,02	62,71	26,30	62,59	26,57	62,48	26,84	62,36	27,12	62,24	27,39	68
69	63,98	25,85	63,86	26,13	63,75	26,41	63,63	26,68	63,52	26,96	63,40	27,23	63,28	27,52	63,16	27,79	69
70	64,90	26,22	64,79	26,51	64,67	26,79	64,55	27,07	64,44	27,35	64,32	27,63	64,19	27,91	64,07	28,19	70
71	65,83	26,60	65,71	26,89	65,60	27,17	65,48	27,46	65,36	27,74	65,23	28,03	65,11	28,31	64,99	28,60	71
72	66,76	26,97	66,64	27,26	66,52	27,55	66,40	27,84	66,28	28,13	66,15	28,42	66,03	28,71	65,90	29,00	72
73	67,69	27,35	67,57	27,64	67,44	27,94	67,31	28,22	67,20	28,52	67,07	28,82	66,95	29,11	66,82	29,40	73
74	68,61	27,72	68,49	28,02	68,37	28,32	68,24	28,62	68,12	28,91	67,99	29,21	67,86	29,50	67,73	29,81	74
75	69,54	28,10	69,42	28,40	69,29	28,70	69,17	29,00	69,04	29,30	68,91	29,61	68,78	29,91	68,65	30,21	75
76	70,47	28,47	70,34	28,78	70,21	29,08	70,09	29,39	69,96	29,69	69,83	30,00	69,70	30,31	69,56	30,61	76
77	71,39	28,85	71,27	29,16	71,14	29,47	71,01	29,78	70,88	30,09	70,71	30,40	70,61	30,71	70,48	31,01	77
78	72,32	29,22	72,19	29,54	72,05	29,85	71,93	30,16	71,80	30,48	71,67	30,79	71,53	31,11	71,39	31,42	78
79	73,25	29,59	73,12	29,91	72,99	30,23	72,8	30,55	72,72	30,87	72,59	31,19	72,45	31,50	72,31	31,82	79
80	74,17	29,97	74,04	30,29	73,91	30,61	73,78	30,94	73,64	31,25	73,50	31,58	73,37	31,90	73,23	32,22	80
81	75,10	30,34	74,97	30,67	74,83	31,00	74,70	31,32	74,56	31,65	74,42	31,97	74,28	32,30	74,14	32,62	81
82	76,03	30,72	75,89	31,05	75,76	31,38	75,62	31,71	75,48	32,04	75,34	32,37	75,20	32,70	75,06	33,03	82
83	76,96	31,09	76,82	31,43	76,68	31,76	76,54	32,09	76,40	32,41	76,26	32,76	76,12	33,10	75,97	33,43	83
84	77,88	31,47	77,75	31,81	77,61	32,15	77,47	32,48	77,32	32,82	77,18	33,15	77,03	33,50	76,89	33,83	84
85	78,81	31,84	78,67	32,19	78,53	32,53	78,39	32,87	78,24	33,21	78,10	33,55	77,95	33,90	77,80	34,24	85
86	79,74	32,22	79,60	32,56	79,45	32,91	79,31	33,26	79,16	33,60	79,02	33,95	78,87	34,29	78,71	34,64	86
87	80,66	32,59	80,52	32,94	80,38	33,29	80,23	33,64	80,08	34,00	79,94	34,34	79,78	34,69	79,63	35,04	87
88	81,59	32,97	81,45	33,32	81,30	33,68	81,18	34,03	81,00	34,39	80,86	34,73	80,71	35,09	80,55	35,44	88
89	82,52	33,34	82,37	33,70	82,23	34,06	82,08	34,42	81,93	34,78	81,77	35,13	81,62	35,49	81,46	35,85	89
90	83,45	33,72	83,30	34,08	83,15	34,44	83,00	34,80	82,85	35,17	82,69	35,53	82,54	35,89	82,38	36,25	90
91	84,37	34,09	84,22	34,46	84,07	34,82	83,92	35,19	83,77	35,56	83,61	35,92	83,46	36,29	83,29	36,65	91
92	85,30	34,46	85,15	34,84	85,00	35,21	84,84	35,57	84,69	35,95	84,53	36,32	84,37	36,69	84,21	37,05	92
93	86,23	34,84	86,08	35,22	85,92	35,59	85,77	35,97	85,61	36,34	85,45	36,71	85,29	37,09	85,12	37,46	93
94	87,16	35,21	87,00	35,59	86,85	35,97	86,69	36,35	86,53	36,73	86,37	37,11	86,20	37,48	86,04	37,86	94
95	88,08	35,59	87,92	35,97	87,77	36,35	87,61	36,74	87,45	37,12	87,29	37,50	87,12	37,88	86,95	38,26	95
96	89,01	35,96	88,85	36,35	88,69	36,74	88,53	37,12	88,37	37,51	88,21	37,90	88,04	38,28	87,87	38,67	96
97	89,94	36,34	89,78	36,73	89,62	37,12	89,45	37,51	89,29	37,90	89,12	38,29	88,95	38,68	88,78	39,07	97
98	90,86	36,71	90,70	37,11	90,54	37,50	90,38	37,9	90,21	38,29	90,04	38,69	89,87	39,08	89,70	39,47	98
99	91,79	37,09	91,63	37,49	91,46	37,89	91,30	38,28	91,13	38,69	90,96	39,08	90,79	39,48	90,61	39,88	99
100	92,72	37,46	92,55	37,87	92,39	38,27	92,22	38,67	92,05	39,07	91,88	39,47	91,71	39,88	91,53	40,28	100
101	93,65	37,84	93,48	38,24	93,31	38,65	93,14	39,05	92,97	39,46	92,80	39,87	92,63	40,28	92,45	40,68	101
102	94,57	38,21	94,41	38,62	94,24	39,03	94,06	39,45	93,89	39,86	93,72	40,26	93,54	40,67	93,36	41,08	102
103	95,50	38,59	95,33	39,00	95,16	39,42	94,98	39,83	94,81	40,25	94,63	40,66	94,46	41,07	94,28	41,48	103
104	96,43	38,96	96,26	39,38	96,08	39,80	95,91	40,22	95,73	40,64	95,56	41,05	95,37	41,47	95,19	41,89	104
105	97,35	39,33	97,18	39,76	97,01	40,18	96,83	40,61	96,64	41,03	96,47	41,41	96,29	41,87	96,11	42,29	105
106	98,28	39,71	98,11	40,14	97,93	40,56	97,75	40,99	97,57	41,42	97,39	41,84	97,21	42,27	97,02	42,69	106
107	99,21	40,08	99,03	40,52	98,86	40,95	98,68	41,38	98,49	41,81	98,31	42,24	98,13	42,67	97,94	43,10	107
108	100,1	40,46	99,96	40,89	99,78	41,33	99,60	41,76	99,41	42,20	99,20						

TRAVERSE TABLE, 712.

24 Degrees																25 Degrees															
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.																	
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.																
1	0,91	0,41	0,91	0,41	0,91	0,42	0,91	0,42	0,91	0,42	0,90	0,43	0,90	0,43	0,90	0,43															
2	1,83	0,81	1,82	0,82	1,82	0,83	1,82	0,84	1,81	0,85	1,81	0,85	1,81	0,86	1,80	0,87															
3	2,74	1,22	2,74	1,23	2,73	1,24	2,72	1,26	2,72	1,27	2,71	1,28	2,71	1,29	2,70	1,30															
4	3,65	1,63	3,65	1,64	3,64	1,66	3,63	1,68	3,63	1,69	3,62	1,71	3,61	1,72	3,60	1,74															
5	4,57	2,03	4,56	2,05	4,55	2,07	4,54	2,09	4,58	2,11	4,52	2,13	4,51	2,15	4,50	2,17															
6	5,48	2,44	5,47	2,46	5,46	2,49	5,45	2,51	5,44	2,54	5,43	2,56	5,42	2,58	5,40	2,61															
7	6,40	2,85	6,38	2,88	6,37	2,90	6,36	2,93	6,34	2,96	6,33	2,99	6,32	3,01	6,31	3,04															
8	7,31	3,25	7,29	3,29	7,28	3,32	7,27	3,35	7,25	3,38	7,24	3,41	7,22	3,44	7,21	3,48															
9	8,22	3,66	8,21	3,70	8,19	3,73	8,17	3,77	8,16	3,80	8,14	3,84	8,12	3,88	8,11	3,91															
10	9,14	4,07	9,12	4,11	9,10	4,15	9,08	4,19	9,06	4,23	9,05	4,27	9,03	4,31	9,01	4,35															
11	10,05	4,47	10,03	4,52	10,01	4,56	9,99	4,61	9,97	4,65	9,95	4,69	9,93	4,74	9,91	4,78															
12	10,96	4,88	10,94	4,93	10,92	4,98	10,90	5,02	10,88	5,07	10,85	5,12	10,83	5,17	10,81	5,21															
13	11,88	5,29	11,85	5,34	11,83	5,39	11,81	5,44	11,78	5,49	11,76	5,55	11,73	5,60	11,71	5,65															
14	12,79	5,69	12,76	5,75	12,74	5,81	12,71	5,86	12,69	5,92	12,66	5,97	12,64	6,03	12,61	6,08															
15	13,70	6,10	13,68	6,16	13,65	6,22	13,62	6,28	13,59	6,34	13,57	6,40	13,54	6,46	13,51	6,52															
16	14,62	6,51	14,59	6,57	14,56	6,64	14,53	6,70	14,50	6,76	14,47	6,83	14,44	6,89	14,41	6,95															
17	15,53	6,91	15,50	6,98	15,47	7,05	15,44	7,12	15,41	7,19	15,37	7,25	15,35	7,32	15,31	7,39															
18	16,44	7,32	16,41	7,39	16,38	7,47	16,35	7,54	16,31	7,61	16,28	7,68	16,25	7,75	16,21	7,82															
19	17,36	7,73	17,32	7,80	17,29	7,88	17,25	7,96	17,22	8,03	17,18	8,11	17,15	8,18	17,11	8,26															
20	18,27	8,14	18,24	8,21	18,20	8,29	18,16	8,37	18,13	8,45	18,09	8,53	18,05	8,61	18,01	8,69															
21	19,18	8,54	19,15	8,63	19,11	8,71	19,07	8,79	19,03	8,88	18,99	8,96	18,96	9,04	18,92	9,12															
22	20,10	8,95	20,06	9,04	20,02	9,12	19,98	9,21	19,94	9,30	19,90	9,39	19,86	9,47	19,82	9,56															
23	21,01	9,36	20,97	9,45	20,94	9,55	20,89	9,63	20,84	9,72	20,80	9,81	20,76	9,90	20,72	9,99															
24	21,93	9,76	21,88	9,86	21,85	9,96	21,80	10,05	21,75	10,14	21,71	10,24	21,66	10,33	21,62	10,43															
25	22,84	10,17	22,79	10,27	22,75	10,38	22,70	10,47	22,66	10,57	22,61	10,67	22,57	10,77	22,52	10,86															
26	23,75	10,58	23,71	10,68	23,66	10,79	23,61	10,89	23,56	10,99	23,51	11,09	23,47	11,20	23,42	11,30															
27	24,67	10,98	24,62	11,09	24,57	11,21	24,52	11,31	24,47	11,41	24,42	11,52	24,37	11,63	24,32	11,73															
28	25,58	11,39	25,53	11,50	25,48	11,62	25,43	11,73	25,37	11,84	25,32	11,95	25,28	12,06	25,22	12,17															
29	26,49	11,80	26,44	11,91	26,39	12,04	26,34	12,14	26,28	12,26	26,23	12,37	26,18	12,49	26,12	12,60															
30	27,41	12,20	27,35	12,32	27,30	12,44	27,24	12,56	27,19	12,68	27,13	12,80	27,08	12,92	27,02	13,03															
31	28,32	12,61	28,26	12,73	28,21	12,86	28,15	12,98	28,10	13,10	28,04	13,22	27,98	13,35	27,92	13,47															
32	29,23	13,02	29,18	13,14	29,12	13,27	29,06	13,40	29,00	13,53	28,94	13,65	28,88	13,78	28,82	13,90															
33	30,15	13,42	30,09	13,55	30,03	13,69	29,97	13,82	29,91	13,95	29,85	14,08	29,79	14,21	29,72	14,34															
34	31,06	13,83	31,00	13,97	30,94	14,10	30,88	14,24	30,81	14,37	30,75	14,51	30,69	14,64	30,62	14,77															
35	31,97	14,24	31,91	14,38	31,85	14,51	31,78	14,66	31,72	14,79	31,65	14,93	31,59	15,07	31,53	15,21															
36	32,89	14,64	32,82	14,79	32,76	14,93	32,69	15,07	32,63	15,22	32,56	15,36	32,50	15,50	32,43	15,64															
37	33,80	15,05	33,73	15,20	33,67	15,35	33,60	15,49	33,53	15,64	33,46	15,79	33,40	15,93	33,33	16,08															
38	34,72	15,46	34,65	15,61	34,58	15,76	34,51	15,91	34,44	16,06	34,37	16,21	34,30	16,36	34,23	16,51															
39	35,63	15,86	35,56	16,02	35,49	16,18	35,42	16,33	35,34	16,49	35,28	16,64	35,21	16,79	35,13	16,94															
40	36,54	16,27	36,47	16,43	36,40	16,59	36,33	16,75	36,25	16,91	36,18	17,07	36,10	17,22	36,03	17,38															
41	37,46	16,68	37,38	16,84	37,31	17,00	37,23	17,17	37,16	17,33	37,08	17,49	37,01	17,65	36,93	17,81															
42	38,37	17,08	38,29	17,25	38,22	17,42	38,14	17,58	38,06	17,75	37,99	17,92	37,92	18,08	37,83	18,25															
43	39,28	17,49	39,20	17,66	39,13	17,83	39,05	18,00	38,97	18,18	38,89	18,34	38,82	18,51	38,73	18,68															
44	40,20	17,90	40,12	18,07	40,04	18,25	39,96	18,42	39,88	18,60	39,79	18,77	39,72	18,94	39,63	19,12															
45	41,11	18,30	41,03	18,48	40,95	18,66	40,87	18,84	40,78	19,02	40,70	19,20	40,62	19,38	40,53	19,55															
46	42,02	18,71	41,94	18,89	41,86	19,08	41,77	19,26	41,69	19,45	41,60	19,63	41,52	19,81	41,43	19,99															
47	42,94	19,12	42,85	19,30	42,77	19,49	42,68	19,68	42,59	19,87	42,51	20,05	42,42	20,24	42,33	20,42															
48	43,85	19,52	43,76	19,72	43,68	19,91	43,59	20,10	43,50	20,29	43,41	20,48	43,32	20,67	43,23	20,85															
49	44,76	19,93	44,68	20,13	44,59	20,32	44,50	20,52	44,41	20,72	44,31	20,91	44,23	21,10	44,13	21,29															
50	45,68	20,34	45,59	20,54	45,50	20,74	45,41	20,93	45,32	21,13	45,22	21,33	45,14	21,53	45,04	21,72															
51	46,59	20,74	46,50	20,95	46,41	21,15	46,32	21,35	46,22	21,55	46,13	21,76	46,03	21,96	45,94	22,16															
52	47,51	21,15	47,41	21,36	47,32	21,57	47,22	21,77	47,13	21,98	47,03	22,18	46,94	22,39	46,84	22,59															
53	48,42	21,56	48,32	21,77	48,23	21,98	48,13	22,19	48,03	22,40	47,94	22,61	47,84	22,82	47,74	23,03															
54	49,33	21,96	49,23	22,18	49,14	22,40	49,04	22,61	48,95	22,82	48,84	23,04	48,74	23,25	48,64	23,46															
55	50,25	22,37	50,15	22,59	50,05	22,81	49,95	23,03	49,85	23,24	49,74	23,46	49,65	23,68	49,54	23,90															
56	51,16	22,78	51,06	23,00	50,96	23,23	50,86	23,45	50,75	23,67	50,65	23,89	50,55	24,11	50,44	24,33															
57	52,07	23,18	51,97	23,41	51,87	23,64	51,76	23,87	51,66	24,09	51,55	24,32	51,45	24,54	51,34	24,77															
58	52,98	23,59	52,88	23,82	52,78	24,06	52,68	24,29	52,56	24,52	52,45	24,75	52,35	24,97	52,24	25,20															
59	53,90	24,00	53,79	24,23	53,69	24,47	53,58	24,70	53,47	24,94	53,36	25,17	53,26	25,41	53,14	25,63															
60	54,81	24,40	54,71	24,64	54,60	24,88	54,40	25,12	54,38	25,36	54,27	25,59	54,16	25,83	54,04	26,07															
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.															
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.																
	66 Deg.																														

TRAVERSE TABLE, 712:

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Distance	24 Degrees								25 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	55,73	24,81	55,62	25,06	55,51	25,30	55,40	25,54	55,29	25,78	55,17	26,02	55,06	26,26	54,94	26,51	61
62	56,64	25,22	56,53	25,47	56,42	25,71	56,30	25,96	56,19	26,20	56,08	26,45	55,96	26,69	55,84	26,94	62
63	57,56	25,63	57,44	25,88	57,33	26,13	57,21	26,38	57,10	26,63	56,98	26,88	56,86	27,12	56,75	27,37	63
64	58,47	26,03	58,35	26,29	58,24	26,54	58,12	26,80	58,00	27,05	57,88	27,30	57,77	27,56	57,65	27,80	64
65	59,38	26,44	59,27	26,70	59,15	26,96	59,03	27,22	58,91	27,47	58,79	27,73	58,67	27,99	58,55	28,24	65
66	60,30	26,85	60,18	27,11	60,06	27,37	59,94	27,63	59,82	27,90	59,69	28,16	59,57	28,42	59,45	28,67	66
67	61,21	27,26	61,09	27,52	60,97	27,79	60,84	28,05	60,72	28,32	60,60	28,58	60,48	28,85	60,35	29,11	67
68	62,13	27,66	62,00	27,93	61,88	28,20	61,75	28,47	61,63	28,74	61,50	29,01	61,38	29,38	61,25	29,54	68
69	63,04	28,07	62,91	28,34	62,79	28,62	62,66	28,89	62,53	29,16	62,40	29,44	62,28	29,71	62,15	29,97	69
70	63,95	28,47	63,82	28,75	63,70	29,03	63,57	29,31	63,44	29,58	63,31	29,86	63,18	30,14	63,05	30,41	70
71	64,86	28,88	64,74	29,16	64,61	29,44	64,48	29,73	64,35	30,01	64,22	30,29	64,08	30,57	63,95	30,85	71
72	65,78	29,29	65,65	29,57	65,52	29,86	65,39	30,14	65,25	30,43	65,12	30,72	64,99	30,99	64,85	31,28	72
73	66,69	29,69	66,56	29,98	66,43	30,27	66,29	30,56	66,16	30,85	66,02	31,15	65,89	31,43	65,75	31,71	73
74	67,61	30,10	67,47	30,39	67,34	30,69	67,20	30,98	67,07	31,28	66,94	31,58	66,79	31,86	66,65	32,15	74
75	68,52	30,51	68,39	30,81	68,25	31,10	68,11	31,40	67,97	31,70	67,84	32,00	67,70	32,29	67,55	32,58	75
76	69,43	30,91	69,30	31,22	69,16	31,52	69,02	31,82	68,88	32,12	68,75	32,42	68,60	32,72	68,46	33,02	76
77	70,35	31,32	70,21	31,63	70,07	31,93	69,93	32,24	69,78	32,54	69,65	32,85	69,50	33,15	69,36	33,45	77
78	71,26	31,73	71,12	32,04	70,98	32,35	70,83	32,66	70,69	32,97	70,55	33,28	70,41	33,58	70,26	33,88	78
79	72,18	32,14	72,03	32,45	71,89	32,76	71,74	33,08	71,60	33,39	71,46	33,70	71,31	33,92	71,16	34,32	79
80	73,08	32,54	72,94	32,86	72,80	33,18	72,65	33,49	72,51	33,81	72,36	34,13	72,21	34,44	72,06	34,76	80
81	74,00	32,95	73,85	33,27	73,71	33,59	73,56	33,91	73,41	34,23	73,26	34,55	73,11	34,87	72,96	35,19	81
82	74,91	33,35	74,77	33,68	74,62	34,00	74,47	34,33	74,32	34,66	74,17	34,98	74,01	35,30	73,86	35,62	82
83	75,83	33,76	75,68	34,09	75,53	34,42	75,38	34,75	75,22	35,08	75,07	35,41	74,92	35,73	74,76	36,06	83
84	76,74	34,17	76,59	34,50	76,44	34,84	76,28	35,17	76,13	35,50	75,97	35,83	75,82	36,17	75,66	36,49	84
85	77,65	34,57	77,50	34,91	77,35	35,25	77,19	35,59	77,04	35,93	76,88	36,26	76,72	36,60	76,56	36,93	85
86	78,57	34,98	78,41	35,32	78,26	35,67	78,10	36,01	77,94	36,35	77,78	36,69	77,63	37,03	77,46	37,36	86
87	79,48	35,39	79,33	35,74	79,17	36,08	79,01	36,43	78,85	36,77	78,69	37,12	78,53	37,46	78,36	37,79	87
88	80,40	35,80	80,24	36,15	80,08	36,50	79,92	36,85	79,75	37,19	79,59	37,54	79,43	37,89	79,26	38,23	88
89	81,31	36,21	81,15	36,56	80,99	36,91	80,83	37,26	80,66	37,62	80,49	37,97	80,33	38,33	80,16	38,66	89
90	82,22	36,61	82,06	36,97	81,90	37,32	81,73	37,68	81,57	38,04	81,40	38,39	81,23	38,75	81,06	39,10	90
91	83,13	37,01	82,97	37,38	82,81	37,74	82,64	38,10	82,47	38,46	82,31	38,82	82,14	39,18	81,96	39,54	91
92	84,05	37,42	83,88	37,79	83,72	38,15	83,55	38,52	83,38	38,88	83,21	39,25	83,04	39,61	82,87	39,97	92
93	84,96	37,83	84,79	38,20	84,63	38,57	84,46	38,94	84,29	39,31	84,11	39,67	83,94	40,04	83,77	40,40	93
94	85,84	38,24	85,71	38,61	85,54	38,98	85,37	39,36	85,19	39,73	85,02	40,10	84,85	40,47	84,66	40,84	94
95	86,89	38,61	86,62	39,02	86,45	39,40	86,27	39,76	86,10	40,15	85,92	40,53	85,75	40,90	85,57	41,27	95
96	87,70	39,02	87,52	39,43	87,36	39,81	87,18	40,18	87,00	40,57	86,83	40,95	86,65	41,33	86,47	41,71	96
97	88,62	39,43	88,44	39,84	88,27	40,23	88,09	40,60	87,91	41,00	87,73	41,38	87,55	41,73	87,37	42,14	97
98	89,53	39,83	89,35	40,25	89,18	40,64	89,00	41,02	88,82	41,42	88,63	41,81	88,46	42,19	88,27	42,57	98
99	90,42	40,24	90,26	40,66	90,09	41,06	89,91	41,44	89,73	41,84	89,54	42,23	89,36	42,63	89,17	43,01	99
100	91,36	40,67	91,18	41,07	91,00	41,47	90,81	41,87	90,63	42,26	90,45	42,66	90,26	43,05	90,07	43,45	100
101	92,27	41,08	92,09	41,48	91,91	41,88	91,72	42,29	91,54	42,69	91,35	43,08	91,16	43,48	90,97	43,88	101
102	93,18	41,49	93,00	41,89	92,82	42,30	92,63	42,70	92,44	43,11	92,25	43,51	92,07	43,91	91,87	44,31	102
103	94,10	41,90	93,91	42,31	93,73	42,71	93,54	43,12	93,35	43,53	93,16	43,94	92,97	44,34	92,77	44,75	103
104	95,01	42,30	94,82	42,72	94,64	43,13	94,45	43,54	94,26	43,95	94,06	44,37	93,87	44,78	93,67	45,18	104
105	95,9	42,71	95,74	43,13	95,55	43,54	95,35	43,96	95,16	44,38	94,97	44,79	94,77	45,21	94,58	45,62	105
106	96,83	43,12	96,65	43,54	96,46	43,96	96,26	44,38	96,07	44,80	95,87	45,22	95,68	45,64	95,48	46,05	106
107	97,75	43,52	97,56	43,95	97,37	44,37	97,17	44,80	96,97	45,22	96,77	45,65	96,59	46,07			

TRAVERSE TABLE, 712.

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Distance	26 Degrees								27 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	54,83	26,74	54,71	26,98	54,59	27,22	54,47	27,46	54,35	27,69	54,23	27,93	54,11	28,17	53,98	28,40	61
62	55,73	27,18	55,61	27,42	55,49	27,66	55,37	27,91	55,24	28,15	55,12	28,39	55,00	28,63	54,87	28,87	62
63	56,62	27,6	56,50	27,86	56,38	28,11	56,26	28,36	56,13	28,6	56,02	28,85	55,88	29,09	55,75	29,34	63
64	57,52	28,05	57,40	28,31	57,28	28,56	57,15	28,81	57,03	29,06	56,90	29,30	56,77	29,55	56,64	29,80	64
65	58,42	28,49	58,30	28,75	58,17	29,00	58,01	29,26	57,92	29,51	57,79	29,76	57,66	30,02	57,52	30,27	65
66	59,32	28,93	59,19	29,19	59,07	29,45	58,94	29,71	58,81	29,96	58,68	30,22	58,54	30,48	58,41	30,73	66
67	60,22	29,37	60,09	29,63	59,96	29,89	59,83	30,16	59,70	30,42	59,56	30,68	59,43	30,94	59,29	31,20	67
68	61,12	29,81	60,99	30,07	60,86	30,34	60,72	30,61	60,59	30,87	60,45	31,14	60,32	31,40	60,18	31,67	68
69	62,02	30,24	61,89	30,52	61,75	30,79	61,62	31,06	61,48	31,33	61,34	31,59	61,20	31,86	61,06	32,13	69
70	62,92	30,69	62,78	30,96	62,65	31,23	62,51	31,51	62,37	31,78	62,25	32,06	62,09	32,32	61,95	32,59	70
71	63,81	31,12	63,68	31,4	63,54	31,68	63,40	31,96	63,26	32,23	63,12	32,51	62,98	32,79	62,83	33,06	71
72	64,71	31,56	64,58	31,84	64,44	32,13	64,30	32,41	64,15	32,69	64,01	32,97	63,87	33,25	63,72	33,53	72
73	65,61	32,00	65,47	32,29	65,33	32,57	65,19	32,86	65,04	33,14	64,90	33,43	64,75	33,71	64,60	33,99	73
74	66,51	32,44	66,37	32,73	66,23	33,02	66,08	33,31	65,94	33,60	65,79	33,88	65,64	34,17	65,49	34,46	74
75	67,41	32,88	67,27	33,17	67,12	33,46	66,97	33,76	66,83	34,05	66,68	34,34	66,53	34,63	66,37	34,92	75
76	68,31	33,31	68,17	33,61	68,02	33,91	67,87	34,21	67,72	34,5	67,57	34,80	67,41	35,10	67,26	35,39	76
77	69,21	33,75	69,06	34,05	68,91	34,36	68,77	34,66	68,61	34,96	68,45	35,26	68,30	35,56	68,14	35,86	77
78	70,11	34,19	69,96	34,50	69,81	34,8	69,65	35,11	69,50	35,41	69,34	35,72	69,19	36,02	69,03	36,32	78
79	71,01	34,63	70,86	34,94	70,70	35,25	70,55	35,56	70,39	35,87	70,23	36,17	70,07	36,48	69,91	36,79	79
80	71,90	35,07	71,75	35,38	71,59	35,70	71,44	36,01	71,28	36,32	71,12	36,63	70,96	36,94	70,80	37,25	80
81	72,80	35,51	72,65	35,83	72,49	36,14	72,33	36,46	72,17	36,77	72,01	37,09	71,85	37,40	71,68	37,72	81
82	73,70	35,95	73,54	36,27	73,38	36,59	73,22	36,91	73,06	37,23	72,90	37,55	72,74	37,86	72,57	38,18	82
83	74,60	36,38	74,44	36,71	74,28	37,03	74,12	37,36	73,95	37,68	73,79	38,00	73,62	38,33	73,46	38,65	83
84	75,50	36,82	75,34	37,15	75,17	37,48	75,01	37,81	74,85	38,14	74,68	38,46	74,51	38,79	74,34	39,11	84
85	76,40	37,26	76,24	37,59	76,07	37,93	75,90	38,2	75,74	38,59	75,57	38,92	75,40	39,25	75,23	39,58	85
86	77,30	37,70	77,13	38,04	76,96	38,37	76,80	38,71	76,63	39,04	76,46	39,38	76,28	39,71	76,11	40,05	86
87	78,20	38,14	78,03	38,48	77,86	38,82	77,69	39,16	77,52	39,50	77,35	39,84	77,17	40,17	77,00	40,51	87
88	79,10	38,57	78,93	38,92	78,75	39,26	78,58	39,61	78,41	39,95	78,23	40,29	78,06	40,64	77,88	40,98	88
89	79,99	39,01	79,82	39,36	79,65	39,71	79,48	40,06	79,30	40,41	79,13	40,75	78,94	41,10	78,77	41,44	89
90	80,89	39,45	80,72	39,81	80,54	40,16	80,37	40,51	80,19	40,86	80,01	41,21	79,83	41,56	79,65	41,91	90
91	81,79	39,89	81,62	40,25	81,44	40,60	81,26	40,96	81,08	41,31	80,90	41,67	80,72	42,02	80,53	42,37	91
92	82,69	40,33	82,51	40,70	82,33	41,05	82,15	41,41	81,91	41,77	81,79	42,12	81,61	42,48	81,42	42,84	92
93	83,59	40,77	83,41	41,13	83,23	41,50	83,05	41,86	82,80	42,22	82,68	42,58	82,49	42,94	82,30	43,30	93
94	84,49	41,21	84,31	41,57	84,12	41,94	83,94	42,31	83,70	42,68	83,57	43,04	83,38	43,41	83,19	43,77	94
95	85,39	41,64	85,20	42,02	85,02	42,39	84,85	42,76	84,59	43,13	84,46	43,50	84,27	43,87	84,07	44,24	95
96	86,29	42,08	86,10	42,46	85,91	42,83	85,73	43,21	85,48	43,59	85,35	43,96	85,15	44,33	84,96	44,70	96
97	87,19	42,52	87,00	42,90	86,81	43,28	86,62	43,66	86,37	44,04	86,24	44,41	86,04	44,79	85,84	45,17	97
98	88,08	42,96	87,89	43,34	87,70	43,73	87,52	44,11	87,26	44,49	87,12	44,87	86,93	45,25	86,73	45,63	98
99	88,98	43,40	88,79	43,78	88,60	44,17	88,41	44,56	88,15	44,95	88,01	45,33	87,81	45,72	87,61	46,10	99
100	89,88	43,84	89,69	44,23	89,49	44,62	89,30	45,01	89,10	45,40	88,90	45,79	88,70	46,18	88,50	46,56	100
101	90,78	44,28	90,58	44,67	90,39	45,07	90,19	45,46	89,99	45,85	89,79	46,25	89,59	46,64	89,38	47,03	101
102	91,68	44,71	91,48	45,11	91,28	45,51	91,08	45,91	90,88	46,31	90,68	46,70	90,48	47,10	90,27	47,49	102
103	92,58	45,15	92,38	45,56	92,18	45,96	91,98	46,36	91,77	46,76	91,57	47,16	91,36	47,56	91,15	47,96	103
104	93,48	45,59	93,28	46,00	93,07	46,40	92,87	46,81	92,67	47,22	92,46	47,60	92,25	48,02	92,04	48,43	104
105	94,37	46,03	94,17	46,44	93,97	46,85	93,76	47,26	93,56	47,68	93,35	48,06	93,14	48,49	92,92	48,89	105
106	95,27	46,47	95,07	46,88	94,86	47,30	94,66	47,71	94,45	48,12	94,24	48,54	94,02	48,95	93,81	49,36	106
107	96,17	46,90	95,97	47,32	95,76	47,74	95,55	48,16	95,34	48,59	95,13	48,99	94,91	49,41	94,69	49,82	107
108	97,07	47,34	96,86	47,77	96,65	48,19	96,44	48,61	96,23	49,01	96,01	49,45	95,80	49,87	95,58	50,29	108
109	97,97	47,78	97,77	48,21	97,55	48,63	97,34	49,06	97,12	49,49	96,90	49,91	96,68	50,33	96,46	50,76	109
110	98,87	48,22	98,66	48,65	98,44	49,08	98,23	49,51	98,01	49,94	97,79	50,37	97,57	50,79	97,35	51,22	110
111	99,77	48,65	99,55	49,09	99,34	49,53	99,12	49,96	98,91	50,39	98,68	50,82	98,46	51,26	98,23	51,68	111
112	100,7	49,10	100,5	49,54	100,2	49,97	100,0	50,41	99,80	50,85	99,57	51,28	99,35	51,72	99,12	52,15	112
113	101,6	49,54	101,3	49,98	101,0	50,42	100,9	50,86	100,7	51,30	100,4	51,74	100,2	52,18	100,0	52,68	113
114	102,5	49,97	102,2	50,42	101,9	50,87	101,8	51,31	101,6	51,76	101,3	52,20	101,1	52,64	100,9	53,08	114
115	103,4	50,41	103,1	50,86	102,8	51,31	102,7	51,76	102,5	52,21	102,2	52,66	102,0	53,10	101,8	53,55	115
116	104,3	50,85	104,0	51,30	103,7	51,76	103,6	52,21	103,4	52,66	103,1	53,11	102,9	53,57	102,7	54,01	116
117	105,2	51,28	104,9	51,75	104,6	52,20	104,5	52,66	104,2	53,12	104,0	53,57	103,8	54,03	103,5	54,49	117
118	106,1	51,72	105,8	52,19	105,5	52,65	105,4	53,11	105,0	53,57	104,9	54,03	104,7	54,49	104,4	54,95	118
119	107,0	52,16	106,7	52,63	106,4	53,10	106,3	53,56	105,0	54,63	105,8	54,49	105,6	54,95	105,3	55,41	119
120	107,9	52,60	107,6	53,08	107,4	53,54	107,2	54,01	106,9	54,48	106,7	54,94	106,4	55,41	106,1	55,87	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	64 Deg.						63 Degrees									62 Degrees	

Distance	28 Degrees								29 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,88	0,47	0,88	0,47	0,88	0,48	0,88	0,48	0,88	0,49	0,87	0,49	0,87	0,49	0,87	0,50	1
2	1,77	0,94	1,76	0,95	1,76	0,95	1,75	0,96	1,75	0,97	1,75	1,00	1,74	0,99	1,74	0,99	2
3	2,65	1,41	2,64	1,42	2,64	1,43	2,63	1,44	2,62	1,46	2,62	1,47	2,61	1,48	2,61	1,49	3
4	3,53	1,88	3,52	1,89	3,52	1,91	3,51	1,92	3,50	1,94	3,49	1,96	3,48	1,97	3,47	1,99	4
5	4,42	2,35	4,40	2,37	4,39	2,39	4,38	2,41	4,37	2,43	4,36	2,45	4,35	2,46	4,34	2,48	5
6	5,30	2,82	5,29	2,84	5,27	2,86	5,26	2,89	5,25	2,91	5,25	2,93	5,22	2,96	5,21	2,98	6
7	6,18	3,29	6,17	3,31	6,15	3,34	6,14	3,37	6,12	3,40	6,11	3,42	6,09	3,45	6,08	3,47	7
8	7,06	3,76	7,05	3,79	7,03	3,82	7,01	3,85	6,99	3,88	6,98	3,91	6,96	3,94	6,95	3,97	8
9	7,95	4,23	7,93	4,27	7,91	4,29	7,89	4,33	7,87	4,37	7,85	4,40	7,83	4,43	7,81	4,47	9
10	8,83	4,70	8,81	4,73	8,79	4,77	8,77	4,81	8,75	4,85	8,73	4,89	8,70	4,92	8,68	4,96	10
11	9,71	5,16	9,69	5,21	9,67	5,25	9,64	5,29	9,62	5,33	9,60	5,38	9,57	5,42	9,55	5,46	11
12	10,60	5,63	10,57	5,68	10,55	5,73	10,52	5,77	10,50	5,82	10,47	5,86	10,44	5,91	10,42	5,96	12
13	11,48	6,10	11,45	6,15	11,42	6,21	11,40	6,25	11,37	6,30	11,34	6,35	11,31	6,40	11,29	6,45	13
14	12,36	6,57	12,33	6,63	12,30	6,68	12,28	6,73	12,25	6,79	12,22	6,84	12,18	6,89	12,15	6,95	14
15	13,24	7,04	13,21	7,10	13,18	7,16	13,15	7,22	13,12	7,27	13,09	7,33	13,05	7,39	13,02	7,44	15
16	14,13	7,51	14,10	7,57	14,06	7,63	14,03	7,70	14,00	7,76	13,96	7,82	13,92	7,88	13,99	7,94	16
17	15,01	7,98	14,98	8,05	14,94	8,11	14,91	8,18	14,87	8,24	14,84	8,31	14,79	8,37	14,86	8,44	17
18	15,89	8,45	15,86	8,52	15,82	8,59	15,79	8,66	15,75	8,73	15,71	8,80	15,66	8,86	15,63	8,93	18
19	16,78	8,92	16,74	8,99	16,70	9,07	16,66	9,14	16,62	9,21	16,58	9,29	16,53	9,35	16,49	9,43	19
20	17,66	9,39	17,62	9,46	17,58	9,54	17,54	9,62	17,49	9,70	17,45	9,77	17,41	9,85	17,36	9,92	20
21	18,54	9,86	18,50	9,94	18,46	10,02	18,41	10,10	18,37	10,18	18,32	10,26	18,28	10,34	18,23	10,42	21
22	19,43	10,33	19,38	10,41	19,33	10,50	19,29	10,58	19,24	10,67	19,20	10,75	19,15	10,83	19,10	10,92	22
23	20,31	10,80	20,26	10,89	20,21	10,97	20,17	11,06	20,12	11,15	20,07	11,24	20,02	11,32	19,97	11,41	23
24	21,19	11,27	21,14	11,36	21,09	11,45	21,04	11,54	20,99	11,64	20,94	11,73	20,89	11,82	20,81	11,91	24
25	22,07	11,73	22,02	11,83	21,97	11,93	21,92	12,03	21,87	12,12	21,82	12,22	21,76	12,31	21,70	12,40	25
26	22,96	12,20	22,90	12,30	22,85	12,41	22,79	12,51	22,74	12,61	22,69	12,71	22,63	12,81	22,57	12,90	26
27	23,84	12,67	23,79	12,78	23,73	12,88	23,67	12,99	23,62	13,09	23,57	13,20	23,50	13,29	23,44	13,40	27
28	24,72	13,14	24,67	13,25	24,61	13,36	24,55	13,47	24,49	13,58	24,43	13,68	24,37	13,78	24,31	13,89	28
29	25,61	13,61	25,55	13,72	25,49	13,83	25,43	13,95	25,37	14,06	25,31	14,17	25,24	14,28	25,18	14,39	29
30	26,49	14,08	26,43	14,20	26,37	14,32	26,30	14,43	26,24	14,54	26,18	14,66	26,11	14,77	26,05	14,89	30
31	27,37	14,55	27,31	14,67	27,24	14,79	27,18	14,91	27,11	15,03	27,05	15,15	26,98	15,27	26,91	15,38	31
32	28,26	15,02	28,19	15,14	28,02	15,27	28,06	15,39	27,99	15,51	27,92	15,64	27,85	15,76	27,78	15,88	32
33	29,14	15,49	29,07	15,62	28,90	15,75	28,93	15,87	28,86	16,00	28,80	16,13	28,72	16,25	28,65	16,38	33
34	30,02	15,96	29,95	16,09	29,78	16,22	29,81	16,35	29,74	16,48	29,67	16,61	29,59	16,74	29,52	16,87	34
35	30,90	16,43	30,83	16,57	30,66	16,70	30,69	16,84	30,61	16,96	30,54	17,10	30,46	17,23	30,39	17,37	35
36	31,79	16,90	31,71	17,04	31,54	17,18	31,56	17,32	31,49	17,45	31,42	17,59	31,33	17,73	31,25	17,86	36
37	32,67	17,37	32,59	17,51	32,42	17,65	32,44	17,80	32,36	17,94	32,29	18,08	32,20	18,22	32,12	18,36	37
38	33,55	17,84	33,48	17,98	33,30	18,13	33,32	18,28	33,24	18,42	33,16	18,57	33,07	18,71	32,99	18,86	38
39	34,44	18,31	34,36	18,46	34,18	18,61	34,20	18,76	34,11	18,99	34,03	19,08	33,94	19,20	33,86	19,35	39
40	35,32	18,78	35,24	18,93	35,15	19,09	35,07	19,24	35,00	19,39	34,91	19,54	34,81	19,70	34,73	19,85	40
41	36,20	19,2	36,12	19,41	36,03	19,56	35,95	19,72	35,85	19,88	35,77	20,03	35,68	20,19	35,60	20,35	41
42	37,08	19,72	37,00	19,88	36,91	20,04	36,82	20,20	36,73	20,36	36,65	20,52	36,55	20,68	36,46	20,85	42
43	37,99	20,19	37,88	20,35	37,79	20,52	37,70	20,68	37,60	20,85	37,52	21,01	37,42	21,17	37,33	21,34	43
44	38,85	20,66	38,76	20,83	38,67	20,99	38,58	21,16	38,48	21,33	38,39	21,50	38,29	21,67	38,20	21,83	44
45	39,73	21,12	39,64	21,30	39,55	21,47	39,45	21,65	39,35	21,82	39,27	21,99	39,16	22,16	39,07	22,33	45
46	40,65	21,59	40,52	21,77	40,43	21,95	40,33	22,13	40,23	22,30	40,14	22,48	40,03	22,65	39,94	22,83	46
47	41,60	22,06	41,40	22,24	41,31	22,43	41,21	22,61	41,10	22,80	41,01	22,97	40,90	23,14	40,80	23,32	47
48	42,41	22,53	42,28	22,72	42,19	22,90	42,09	23,09	42,00	23,28	41,88	23,46	41,77	23,63	41,67	23,82	48
49	43,30	23,00	43,17	23,19	43,06	23,38	42,96	23,57	42,85	23,77	42,76	23,95	42,64	24,13	42,54	24,31	49
50	44,15	23,47	44,05	23,67	43,94	23,86	43,84	24,05	43,73	24,24	43,63	24,43	43,52				

TRAVERSE TABLE, 7127

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Distance	28 Degrees								29 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	53,86	28,64	53,73	28,87	53,61	29,11	53,48	29,34	53,35	29,57	53,22	30,21	53,09	30,44	52,96	30,67	61
62	54,74	29,11	54,62	29,35	54,49	29,58	54,36	29,82	54,23	30,05	54,10	30,29	53,96	30,53	53,83	30,77	62
63	55,63	29,58	55,50	29,82	55,37	30,06	55,24	30,30	55,10	30,54	54,97	30,78	54,83	31,02	54,70	31,26	63
64	56,51	30,04	56,38	30,29	56,25	30,54	56,11	30,78	55,98	31,03	55,84	31,27	55,70	31,51	55,56	31,76	64
65	57,39	30,51	57,26	30,70	57,12	31,02	56,99	31,26	56,85	31,51	56,72	31,70	56,57	32,01	56,43	32,25	65
66	58,28	30,98	58,14	31,24	57,90	31,49	57,77	31,73	57,63	32,00	57,50	32,24	57,34	32,50	57,20	32,75	66
67	59,16	31,45	59,02	31,70	58,78	31,97	58,64	32,23	58,50	32,48	58,36	32,74	58,21	32,99	58,07	33,25	67
68	60,04	31,92	59,90	32,18	59,66	32,05	59,52	32,71	59,38	32,97	59,23	33,23	59,08	33,48	58,94	33,74	68
69	60,92	32,39	60,78	32,66	60,54	32,52	60,40	33,19	60,25	33,46	60,11	33,72	59,96	33,97	59,82	34,24	69
70	61,81	32,86	61,66	33,13	61,52	33,40	61,37	33,67	61,22	33,94	61,08	34,20	60,93	34,41	60,77	34,74	70
71	62,69	33,33	62,54	33,61	62,40	33,88	62,25	34,11	62,10	34,42	61,95	34,69	61,80	34,96	61,64	35,23	71
72	63,57	33,80	63,42	34,08	63,28	34,36	63,13	34,63	62,97	34,91	62,82	35,18	62,67	35,45	62,51	35,73	72
73	64,46	34,27	64,31	34,55	64,15	34,83	64,00	35,11	63,85	35,39	63,69	35,67	63,54	35,95	63,38	36,22	73
74	65,34	34,74	65,19	35,02	65,03	35,31	64,88	35,59	64,72	35,88	64,57	36,10	64,41	36,44	64,25	36,72	74
75	66,22	35,21	66,07	35,50	65,91	35,79	65,76	36,07	65,60	36,36	65,44	36,60	65,28	36,93	65,11	37,22	75
76	67,11	35,68	66,95	35,97	66,79	36,26	66,63	36,56	66,47	36,85	66,31	37,14	66,15	37,42	65,98	37,71	76
77	67,99	36,15	67,83	36,44	67,67	36,74	67,51	37,04	67,35	37,33	67,19	37,63	67,02	37,91	66,85	38,21	77
78	68,87	36,62	68,71	36,92	68,55	37,22	68,39	37,51	68,22	37,82	68,06	38,11	67,89	38,41	67,72	38,70	78
79	69,75	37,08	69,59	37,39	69,43	37,69	69,26	38,00	69,09	38,30	68,93	38,60	68,76	38,90	68,59	39,20	79
80	70,64	37,56	70,47	37,87	70,31	38,17	70,14	38,48	69,97	38,78	69,80	39,09	69,63	39,39	69,46	39,70	80
81	71,52	38,03	71,35	38,34	71,19	38,65	71,02	38,96	70,85	39,27	70,67	39,58	70,50	39,89	70,32	40,29	81
82	72,40	38,50	72,23	38,81	72,06	39,13	71,89	39,44	71,71	39,75	71,55	40,07	71,37	40,38	71,19	40,69	82
83	73,29	38,97	73,11	39,29	72,94	39,61	72,77	39,92	72,59	40,24	72,42	40,56	72,24	40,87	72,06	41,19	83
84	74,17	39,43	74,00	39,76	73,82	40,08	73,65	40,41	73,47	40,72	73,30	41,04	73,11	41,36	72,93	41,68	84
85	75,05	39,90	74,88	40,23	74,70	40,56	74,52	40,88	74,34	41,21	74,17	41,53	73,98	41,84	73,80	42,18	85
86	75,93	40,37	75,76	40,70	75,58	41,04	75,40	41,37	75,21	41,70	75,04	42,02	74,85	42,33	74,66	42,67	86
87	76,82	40,84	76,64	41,18	76,46	41,51	76,28	41,85	76,09	42,18	75,91	42,51	75,72	42,84	75,53	43,17	87
88	77,70	41,31	77,52	41,65	77,34	41,99	77,15	42,33	76,96	42,67	76,78	43,00	76,59	43,33	76,40	43,67	88
89	78,58	41,78	78,40	42,12	78,22	42,47	78,03	42,81	77,84	43,15	77,65	43,49	77,46	43,82	77,27	44,16	89
90	79,47	42,25	79,28	42,60	79,09	42,94	78,91	43,29	78,72	43,63	78,53	43,97	78,33	44,32	78,14	44,66	90
91	80,35	42,72	80,16	43,07	79,97	43,42	79,78	43,77	79,59	44,12	79,40	44,46	79,20	44,81	79,01	45,16	91
92	81,23	43,19	81,04	43,55	80,85	43,90	80,66	44,25	80,47	44,60	80,27	44,95	80,07	45,30	79,87	45,65	92
93	82,12	43,66	81,92	44,02	81,73	44,38	81,54	44,73	81,34	45,09	81,14	45,44	80,94	45,79	80,74	46,15	93
94	83,00	44,13	82,80	44,49	82,61	44,85	82,41	45,21	82,22	45,57	82,02	45,93	81,81	46,29	81,61	46,64	94
95	83,88	44,60	83,69	44,96	83,49	45,33	83,29	45,69	83,09	46,06	82,89	46,42	82,68	46,78	82,48	47,14	95
96	84,76	45,07	84,57	45,44	84,37	45,81	84,17	46,18	83,97	46,54	83,76	46,91	83,55	47,27	83,35	47,64	96
97	85,65	45,54	85,45	45,91	85,25	46,28	85,05	46,66	84,84	47,03	84,64	47,40	84,42	47,76	84,21	48,13	97
98	86,53	46,00	86,33	46,38	86,13	46,76	85,92	47,14	85,72	47,51	85,51	47,89	85,29	48,25	85,08	48,63	98
99	87,41	46,47	87,21	46,86	87,01	47,24	86,80	47,62	86,59	48,00	86,38	48,38	86,16	48,75	85,95	49,12	99
100	88,30	46,95	88,09	47,33	87,88	47,72	87,67	48,11	87,46	48,48	87,25	48,86	87,04	49,24	86,82	49,62	100
101	89,18	47,42	88,97	47,81	88,76	48,19	88,55	48,58	88,34	48,97	88,12	49,35	87,91	49,73	87,69	50,12	101
102	90,06	47,89	89,85	48,28	89,65	48,67	89,43	49,08	89,21	49,45	89,00	49,84	88,78	50,23	88,56	50,61	102
103	90,94	48,36	90,73	48,75	90,52	49,15	90,30	49,54	90,09	49,94	89,87	50,33	89,65	50,72	89,42	51,11	103
104	91,83	48,82	91,61	49,22	91,40	49,62	91,18	50,02	90,96	50,41	90,74	50,82	90,52	51,21	90,29	51,61	104
105	92,71	49,29	92,49	49,70	92,28	50,10	92,06	50,50	91,84	50,91	91,63	51,31	91,39	51,70	91,16	52,10	105
106	93,59	49,76	93,38	50,17	93,16	50,58	92,94	50,99	92,71	51,09	92,49	51,80	92,26	52,19	92,03	52,60	106
107	94,48	50,23	94,26	50,64	94,04	51,06	93,81	51,47	93,59	51,88	93,36	52,28	93,13	52,69	92,90	53,09	107
108	95,36	50															

Distance	30 Degrees								31 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,87	0,50	0,80	0,50	0,86	0,51	0,86	0,51	0,86	0,51	0,85	0,52	0,85	0,52	0,85	0,53	1
2	1,73	1,00	1,73	1,00	1,72	1,01	1,72	1,02	1,71	1,03	1,71	1,04	1,70	1,04	1,70	1,05	2
3	2,60	1,50	2,59	1,51	2,58	1,52	2,58	1,53	2,57	1,54	2,56	1,56	2,56	1,57	2,55	1,58	3
4	3,46	2,00	3,45	2,01	3,45	2,03	3,44	2,04	3,43	2,06	3,42	2,07	3,41	2,09	3,40	2,10	4
5	4,33	2,50	4,32	2,52	4,31	2,54	4,28	2,56	4,29	2,57	4,27	2,59	4,26	2,61	4,25	2,63	5
6	5,2	3,00	5,18	3,02	5,17	3,04	5,16	3,07	5,14	3,09	5,13	3,11	5,12	3,13	5,10	3,16	6
7	6,06	3,50	6,05	3,53	6,03	3,55	6,02	3,58	6,00	3,60	5,98	3,63	5,97	3,66	5,95	3,68	7
8	6,93	4,00	6,91	4,03	6,89	4,06	6,88	4,09	6,86	4,12	6,84	4,15	6,82	4,18	6,80	4,21	8
9	7,79	4,50	7,77	4,53	7,75	4,57	7,73	4,60	7,71	4,63	7,69	4,67	7,67	4,70	7,65	4,74	9
10	8,66	5,00	8,64	5,04	8,62	5,07	8,59	5,11	8,57	5,15	8,55	5,19	8,53	5,22	8,50	5,26	10
11	9,53	5,50	9,50	5,54	9,48	5,58	9,45	5,62	9,43	5,66	9,40	5,71	9,38	5,75	9,35	5,79	11
12	10,39	6,00	10,35	6,04	10,34	6,09	10,31	6,13	10,29	6,18	10,26	6,22	10,23	6,27	10,20	6,31	12
13	11,26	6,50	11,23	6,55	11,20	6,60	11,17	6,65	11,14	6,69	11,11	6,74	11,08	6,79	11,05	6,84	13
14	12,12	7,00	12,09	7,05	12,06	7,10	12,03	7,16	12,00	7,21	11,97	7,26	11,94	7,32	11,90	7,37	14
15	12,99	7,50	12,96	7,56	12,93	7,61	12,89	7,67	12,86	7,72	12,82	7,78	12,79	7,84	12,75	7,89	15
16	13,86	8,00	13,82	8,06	13,79	8,12	13,75	8,18	13,71	8,24	13,68	8,30	13,64	8,36	13,60	8,42	16
17	14,72	8,50	14,69	8,56	14,65	8,63	14,61	8,69	14,57	8,75	14,53	8,82	14,50	8,88	14,45	8,94	17
18	15,59	9,00	15,55	9,07	15,51	9,14	15,47	9,20	15,43	9,27	15,39	9,34	15,35	9,4	15,30	9,47	18
19	16,45	9,50	16,41	9,57	16,37	9,65	16,33	9,71	16,28	9,78	16,24	9,80	16,20	9,93	16,15	10,00	19
20	17,32	10,00	17,28	10,07	17,23	10,15	17,19	10,23	17,14	10,30	17,10	10,37	17,05	10,45	17,01	10,52	20
21	18,19	10,50	18,14	10,58	18,09	10,66	18,05	10,74	18,00	10,82	17,95	10,89	17,91	10,97	17,86	11,05	21
22	19,05	11,00	19,00	11,08	18,96	11,17	18,91	11,25	18,86	11,33	18,81	11,41	18,76	11,50	18,71	11,58	22
23	19,92	11,50	19,87	11,9	19,82	11,67	19,76	11,76	19,71	11,85	19,66	11,93	19,61	12,02	19,56	12,10	23
24	20,78	12,00	20,73	12,09	20,68	12,18	20,62	12,27	20,57	12,36	20,52	12,45	20,46	12,54	20,41	12,63	24
25	21,65	12,50	21,60	12,59	21,54	12,69	21,48	12,78	21,43	12,88	21,37	12,97	21,32	13,06	21,26	13,15	25
26	22,52	13,00	22,46	13,10	22,40	13,20	22,34	13,29	22,28	13,39	22,23	13,49	22,17	13,59	22,11	13,68	26
27	23,38	13,50	23,32	13,60	23,27	13,71	23,20	13,80	23,14	13,91	23,08	14,01	23,02	14,11	22,96	14,21	27
28	24,25	14,00	24,19	14,11	24,13	14,21	24,06	14,31	24,00	14,42	23,94	14,53	23,88	14,63	23,81	14,73	28
29	25,11	14,50	25,05	14,61	24,99	14,72	24,92	14,82	24,86	14,94	24,79	15,05	24,73	15,16	24,66	15,26	29
30	25,98	15,00	25,91	15,11	25,85	15,22	25,78	15,34	25,71	15,45	25,65	15,56	25,58	15,67	25,51	15,79	30
31	26,85	15,50	26,78	15,62	26,71	15,73	26,64	15,85	26,57	15,97	26,50	16,08	26,43	16,20	26,36	16,31	31
32	27,71	16,00	27,64	16,12	27,57	16,24	27,50	16,36	27,43	16,48	27,36	16,60	27,28	16,72	27,21	16,84	32
33	28,58	16,50	28,51	16,62	28,43	16,75	28,36	16,87	28,29	17,00	28,21	17,12	28,14	17,24	28,06	17,36	33
34	29,44	17,00	29,37	17,13	29,30	17,26	29,22	17,38	29,14	17,51	29,07	17,64	28,99	17,77	28,91	17,89	34
35	30,31	17,50	30,23	17,63	30,16	17,77	30,08	17,89	30,00	18,03	29,92	18,16	29,84	18,29	29,76	18,41	35
36	31,18	18,00	31,10	18,14	31,02	18,27	30,94	18,40	30,86	18,54	30,78	18,68	30,70	18,81	30,61	18,94	36
37	32,04	18,50	31,96	18,64	31,88	18,78	31,79	18,92	31,71	19,06	31,63	19,20	31,55	19,34	31,46	19,47	37
38	32,91	19,00	32,83	19,14	32,74	19,29	32,65	19,43	32,57	19,57	32,49	19,71	32,40	19,86	32,31	19,99	38
39	33,77	19,50	33,69	19,65	33,60	19,80	33,51	19,94	33,43	20,09	33,34	20,23	33,26	20,38	33,16	20,52	39
40	34,64	20,00	34,55	20,15	34,40	20,30	34,38	20,45	34,29	20,60	34,20	20,75	34,11	20,90	34,01	21,05	40
41	35,51	20,50	35,42	20,65	35,33	20,81	35,23	20,96	35,14	21,12	35,05	21,27	34,96	21,42	34,86	21,57	41
42	36,37	21,00	36,28	21,16	36,19	21,32	36,09	21,47	36,00	21,63	35,92	21,79	35,81	21,95	35,71	22,10	42
43	37,24	21,50	37,15	21,66	37,05	21,83	36,95	21,98	36,86	22,15	36,76	22,31	36,66	22,47	36,56	22,63	43
44	38,10	22,00	38,01	22,17	37,91	22,33	37,81	22,48	37,71	22,66	37,62	22,83	37,52	22,99	37,41	23,5	44
45	38,97	22,50	38,87	22,67	38,77	22,84	38,67	22,99	38,57	23,18	38,47	23,35	38,37	23,51	38,26	23,68	45
46	39,84	23,00	39,74	23,17	39,64	23,35	39,53	23,50	39,43	23,69	39,33	23,86	39,22	24,04	39,11	24,20	46
47	40,70	23,50	40,60	23,68	40,50	23,86	40,39	24,01	40,29	24,21	40,18	24,38	40,08	24,56	39,96	24,73	47
48	41,57	24,00	41,47	24,18	41,36	24,36	41,25	24,52	41,14	24,72	41,04	24,90	40,93	25,08	40,81	25,26	48
49	42,43	24,50	42,33	24,69	42,22	24,86	42,11	25,03	42,00	25,24	41,89	25,42	41,78	25,61	41,66	25,78	49
50	43,30	25,00	43,19	25,19	43,08	25,36	42,97	25,56	42,86	25,75	42,75	25,94	42,64	26,12	42,52	26,31	50
51	44,16	25,50	44,06	25,69	43,94	25,88	43,83	26,08	43,72	26,27	43,60	26,46	43,48	26,65	43,37	26,84	51
52	45,03	26,00	44,92	26,20	44,81	26,39	44,69	26,59	44,57	26,77	44,46	26,98	44,34	27,17	44,22	27,36	52
53	45,90	26,50	45,78	26,70	45,67	26,90	45,55	27,10	45,45	27,29	45,31	27,50	45,19	27,69	45,07	27,89	53
54	46,76	27,00	46,65	27,20	46,53	27,41	46,41	27,61	46,29	27,80	46,17	28,01	46,04	28,22	45,92	28,41	54
55	47,63	27,50	47,51	27,71	47,39	27,92	47,27	28,12	47,14	28,32	47,02	28,53	46,90	28,74	46,77	28,94	55
56	48,50	28,00	48,38	28,21	48,25	28,42	48,11	28,63	48,00	28,85	47,88	29,05	47,75	29,26	47,62	29,47	56
57	49,36	28,50	49,24	28,72	49,12	28,93	48,98	29,14	48,86	29,35	48,73	29,57	48,60	29,79	48,47	29,00	57
58	50,23	29,00	50,10	29,22	49,98	29,44	49,84	29,65	49,71	29,86	49,59	30,09	49,46	30,31	49,32	30,52	58
59	51,10	29,50	50,97	29,72	50,84	29,95	50,70	30,16	50,57	30,38	50,44	30,61	50,31	30,83	50,17	31,04	59
60	51,96	30,00	51,83	30,23	51,70	30,45	51,56	30,68	51,43	30,90	51,29	31,13	51,16	31,35	51,02	31,57	60
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		Distance
	60 Deg.				59 Degrees				58 Degrees								

TRAVERSE TABLE, 712.

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Distance	30 Degrees								31 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	52,83	30,50	52,69	30,73	52,56	30,96	52,42	31,19	52,29	31,42	52,15	31,64	52,01	31,87	51,87	32,10	61
62	53,69	31,00	53,56	31,23	53,42	31,47	53,28	31,70	53,14	31,93	53,00	32,16	52,86	32,40	52,72	32,62	62
63	54,56	31,50	54,42	31,74	54,28	31,98	54,14	32,21	54,00	32,45	53,86	32,68	53,72	32,92	53,57	33,15	63
64	55,43	32,00	55,29	32,24	55,15	32,48	55,00	32,72	54,86	32,96	54,71	33,20	54,57	33,44	54,42	33,68	64
65	56,29	32,50	56,15	32,75	56,01	32,99	55,86	33,23	55,71	33,48	55,57	33,72	55,42	33,96	55,27	34,20	65
66	57,16	33,00	57,01	33,25	56,87	33,50	56,72	33,74	56,57	33,99	56,42	34,24	56,28	34,49	56,12	34,73	66
67	58,02	33,50	57,88	33,75	57,73	34,01	57,58	34,25	57,43	34,51	57,28	34,76	57,13	35,01	56,97	35,25	67
68	58,89	34,00	58,74	34,26	58,59	34,52	58,44	34,76	58,29	35,02	58,13	35,28	57,98	35,53	57,82	35,78	68
69	59,76	34,50	59,61	34,76	59,46	35,02	59,30	35,28	59,14	35,54	58,99	35,80	58,83	36,06	58,67	36,31	69
70	60,62	35,00	60,47	35,26	60,31	35,53	60,16	35,79	60,00	36,05	59,84	36,31	59,68	36,57	59,52	36,83	70
71	61,49	35,50	61,33	35,77	61,18	36,04	61,02	36,30	60,86	36,57	60,70	36,83	60,54	37,09	60,37	37,36	71
72	62,35	36,00	62,20	36,27	62,04	36,54	61,88	36,81	61,72	37,08	61,55	37,35	61,39	37,62	61,22	37,89	72
73	63,22	36,50	63,06	36,78	62,90	37,05	62,74	37,32	62,57	37,60	62,41	37,87	62,24	38,14	62,07	38,41	73
74	64,09	37,00	63,92	37,28	63,76	37,56	63,59	37,83	63,42	38,11	63,26	38,39	63,10	38,67	62,92	38,94	74
75	64,95	37,50	64,79	37,78	64,62	38,07	64,45	38,34	64,28	38,63	64,12	38,91	63,95	39,19	63,77	39,46	75
76	65,82	38,00	65,65	38,29	65,49	38,58	65,31	38,86	65,13	39,14	64,97	39,43	64,82	39,71	64,62	39,99	76
77	66,68	38,50	66,52	38,79	66,35	39,08	66,17	39,37	65,99	39,66	65,83	39,95	65,66	40,23	65,47	40,52	77
78	67,55	39,00	67,38	39,30	67,21	39,59	67,03	39,88	66,86	40,17	66,68	40,47	66,51	40,76	66,32	41,04	78
79	68,42	39,50	68,24	39,80	68,07	40,10	67,89	40,39	67,70	40,69	67,54	40,92	67,36	41,28	67,17	41,57	79
80	69,28	40,00	69,11	40,30	68,93	40,60	68,75	40,90	68,57	41,20	68,39	41,50	68,21	41,80	68,03	42,10	80
81	70,15	40,50	69,97	40,81	69,79	41,11	69,61	41,41	69,43	41,72	69,25	42,02	69,06	42,32	68,88	42,62	81
82	71,01	41,00	70,83	41,31	70,65	41,62	70,47	41,92	70,29	42,23	70,10	42,54	69,92	42,85	69,73	43,15	82
83	71,88	41,50	71,70	41,81	71,52	42,13	71,33	42,44	71,14	42,75	70,96	43,06	70,77	43,37	70,58	43,67	83
84	72,75	42,00	72,56	42,32	72,38	42,63	72,19	42,95	72,00	43,26	71,81	43,58	71,62	43,89	71,43	44,20	84
85	73,61	42,50	73,43	42,82	73,24	43,14	73,05	43,46	72,86	43,78	72,67	44,10	72,48	44,41	72,28	44,73	85
86	74,48	43,00	74,29	43,32	74,10	43,65	73,91	43,97	73,72	44,29	73,52	44,62	73,33	44,94	73,13	45,25	86
87	75,34	43,50	75,15	43,83	74,96	44,16	74,77	44,48	74,57	44,81	74,38	45,13	74,18	45,46	73,98	45,78	87
88	76,21	44,00	76,02	44,33	75,83	44,67	75,62	44,99	75,43	45,32	75,23	45,65	75,03	45,98	74,83	46,30	88
89	77,08	44,50	76,88	44,84	76,69	45,17	76,48	45,50	76,29	45,84	76,09	46,17	75,89	46,51	75,68	46,83	89
90	77,94	45,00	77,75	45,34	77,55	45,68	77,35	46,02	77,14	46,35	76,94	46,69	76,74	47,02	76,53	47,36	90
91	78,81	45,50	78,61	45,84	78,41	46,19	78,21	46,53	78,00	46,87	77,80	47,21	77,59	47,55	77,38	47,88	91
92	79,67	46,00	79,47	46,33	79,27	46,69	79,06	47,04	78,86	47,38	78,65	47,73	78,44	48,07	78,23	48,41	92
93	80,54	46,50	80,34	46,85	80,13	47,20	79,92	47,55	79,72	47,90	79,51	48,24	79,30	48,59	79,08	48,94	93
94	81,41	47,00	81,20	47,35	80,99	47,71	80,78	48,06	80,57	48,41	80,36	48,76	80,15	49,12	79,93	49,46	94
95	82,27	47,50	82,07	47,86	81,86	48,22	81,64	48,57	81,43	48,93	81,22	49,28	81,01	49,64	80,78	49,99	95
96	83,14	48,00	82,93	48,36	82,73	48,73	82,50	49,08	82,29	49,44	82,07	49,80	81,86	50,16	81,63	50,52	96
97	84,00	48,50	83,79	48,87	83,58	49,23	83,36	49,59	83,14	49,96	82,93	50,32	82,71	50,69	82,48	51,04	97
98	84,87	49,00	84,66	49,37	84,44	49,74	84,22	50,10	84,00	50,47	83,78	50,84	83,57	51,21	83,33	51,57	98
99	85,74	49,50	85,52	49,87	85,29	50,25	85,08	50,61	84,86	50,99	84,64	51,36	84,42	51,73	84,18	52,09	99
100	86,60	50,00	86,38	50,38	86,16	50,75	85,94	51,13	85,72	51,50	85,49	51,88	85,26	52,25	85,03	52,62	100
101	87,47	50,50	87,25	50,88	87,02	51,26	86,80	51,64	86,57	52,02	86,35	52,40	86,12	52,77	85,88	53,15	101
102	88,33	51,00	88,11	51,38	87,89	51,77	87,66	52,15	87,43	52,53	87,20	52,91	86,97	53,30	86,73	53,67	102
103	89,20	51,50	88,90	51,89	88,75	52,28	88,52	52,66	88,29	53,05	88,06	53,43	87,82	53,82	87,58	54,20	103
104	90,07	52,00	89,84	52,38	89,61	52,79	89,38	53,17	89,14	53,56	88,91	53,95	88,68	54,34	88,43	54,72	104
105	90,93	52,50	90,70	52,90	90,47	53,29	90,24	53,68	90,00	54,08	89,77	54,47	89,53	54,87	89,28	55,25	105
106	91,80	53,00	91,57	53,40	91,33	53,80	91,09	54,19	90,86	54,59	90,62	54,99	90,38	55,39	90,13	55,78	106
107	92,66	53,50	92,43	53,90	92,20	54,31	91,95	54,71	91,72	55,11	91,48	55,51	91,23	55,91	90,98		

TRAVERSE TABLE, 712.

Distance	32 Degrees								33 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,83	0,53	0,85	0,53	0,84	0,54	0,84	0,54	0,84	0,54	0,84	0,55	0,83	0,55	0,83	0,56	1
2	1,70	1,06	1,69	1,07	1,69	1,07	1,68	1,08	1,68	1,09	1,67	1,10	1,67	1,10	1,66	1,11	2
3	2,54	1,59	2,54	1,60	2,53	1,61	2,52	1,62	2,52	1,63	2,51	1,64	2,50	1,66	2,49	1,67	3
4	3,39	2,12	3,38	2,13	3,37	2,13	3,36	2,16	3,35	2,18	3,34	2,19	3,34	2,21	3,33	2,22	4
5	4,24	2,65	4,23	2,67	4,22	2,69	4,20	2,70	4,19	2,72	4,18	2,74	4,17	2,76	4,16	2,78	5
6	5,09	3,18	5,07	3,20	5,06	3,22	5,05	3,25	5,03	3,27	5,02	3,29	5,00	3,31	4,99	3,33	6
7	5,94	3,71	5,92	3,73	5,90	3,76	5,89	3,79	5,87	3,81	5,85	3,84	5,84	3,86	5,82	3,89	7
8	6,78	4,24	6,77	4,27	6,75	4,30	6,73	4,33	6,71	4,36	6,69	4,39	6,67	4,42	6,65	4,45	8
9	7,63	4,77	7,61	4,80	7,59	4,84	7,57	4,87	7,55	4,90	7,53	4,93	7,50	4,97	7,48	5,00	9
10	8,48	5,30	8,46	5,34	8,43	5,37	8,41	5,41	8,39	5,45	8,38	5,48	8,34	5,52	8,32	5,56	10
11	9,33	5,83	9,30	5,87	9,27	5,91	9,25	5,95	9,22	5,99	9,20	6,03	9,17	6,07	9,15	6,11	11
12	10,18	6,36	10,15	6,40	10,12	6,45	10,09	6,49	10,06	6,54	10,03	6,58	10,01	6,62	9,98	6,67	12
13	11,03	6,89	10,99	6,94	10,96	6,98	10,91	7,03	10,90	7,08	10,87	7,13	10,84	7,17	10,81	7,22	13
14	11,87	7,42	11,84	7,47	11,81	7,52	11,75	7,57	11,74	7,63	11,71	7,67	11,67	7,73	11,64	7,78	14
15	12,72	7,95	12,69	8,00	12,65	8,06	12,59	8,11	12,58	8,17	12,54	8,22	12,51	8,28	12,47	8,31	15
16	13,57	8,48	13,53	8,60	13,49	8,66	13,44	8,65	13,42	8,72	13,38	8,77	13,34	8,83	13,30	8,89	16
17	14,42	9,01	14,38	9,07	14,34	9,13	14,28	9,19	14,26	9,26	14,21	9,32	14,18	9,38	14,13	9,45	17
18	15,26	9,54	15,22	9,67	15,18	9,67	15,12	9,73	15,10	9,81	15,05	9,87	15,01	9,93	14,96	9,99	18
19	16,11	10,07	16,07	10,24	16,02	10,21	15,96	10,27	15,94	10,35	15,89	10,41	15,84	10,49	15,80	10,56	19
20	16,96	10,60	16,91	10,67	16,87	10,75	16,82	10,82	16,77	10,89	16,73	10,97	16,68	11,04	16,63	11,12	20
21	17,81	11,13	17,76	11,21	17,71	11,28	17,66	11,36	17,61	11,44	17,56	11,51	17,51	11,59	17,46	11,67	21
22	18,65	11,66	18,61	11,74	18,55	11,82	18,50	11,90	18,45	11,98	18,40	12,06	18,35	12,14	18,29	12,22	22
23	19,50	12,19	19,45	12,27	19,40	12,35	19,34	12,44	19,29	12,53	19,23	12,61	19,18	12,69	19,12	12,78	23
24	20,35	12,72	20,30	12,81	20,24	12,90	20,18	12,98	20,13	13,07	20,07	13,16	20,01	13,25	19,95	13,34	24
25	21,20	13,25	21,14	13,34	21,08	13,44	21,03	13,52	20,97	13,62	20,91	13,71	20,85	13,80	20,78	13,89	25
26	22,05	13,78	21,99	13,88	21,93	13,97	21,87	14,06	21,81	14,16	21,74	14,25	21,68	14,35	21,62	14,43	26
27	22,90	14,31	22,84	14,41	22,77	14,51	22,61	14,61	22,65	14,71	22,58	14,80	22,52	14,90	22,45	15,00	27
28	23,74	14,84	23,68	14,94	23,62	15,05	23,45	15,15	23,48	15,25	23,41	15,35	23,35	15,45	23,28	15,56	28
29	24,59	15,37	24,53	15,48	24,45	15,58	24,39	15,69	24,32	15,80	24,25	15,90	24,18	16,01	24,11	16,12	29
30	25,44	15,90	25,37	16,01	25,30	16,12	25,23	16,23	25,16	16,34	25,09	16,45	25,02	16,56	24,94	16,67	30
31	26,29	16,43	26,22	16,54	26,14	16,66	26,07	16,77	26,00	16,88	25,92	17,00	25,85	17,11	25,78	17,22	31
32	27,14	16,96	27,06	17,08	26,99	17,19	26,91	17,31	26,84	17,43	26,76	17,54	26,68	17,66	26,61	17,78	32
33	27,99	17,49	27,91	17,61	27,83	17,73	27,75	17,85	27,68	17,97	27,60	18,09	27,52	18,21	27,44	18,34	33
34	28,83	18,02	28,76	18,14	28,67	18,27	28,59	18,39	28,52	18,52	28,43	18,64	28,35	18,77	28,27	18,89	34
35	29,68	18,55	29,60	18,68	29,51	18,80	29,44	18,93	29,35	19,06	29,27	19,19	29,19	19,32	29,10	19,45	35
36	30,53	19,08	30,45	19,21	30,36	19,33	30,28	19,47	30,19	19,61	30,10	19,74	30,02	19,87	29,93	20,00	36
37	31,38	19,61	31,29	19,75	31,20	19,88	31,12	20,02	31,03	20,15	30,94	20,28	30,85	20,42	30,76	20,56	37
38	32,23	20,14	32,14	20,28	32,05	20,41	31,96	20,56	31,87	20,70	31,78	20,83	31,69	20,97	31,59	21,13	38
39	33,07	20,67	32,99	20,81	32,89	20,95	32,80	21,10	32,71	21,24	32,61	21,38	32,52	21,53	32,42	21,67	39
40	33,92	21,20	33,83	21,34	33,76	21,49	33,64	21,64	33,55	21,79	33,45	21,93	33,36	22,08	33,26	22,22	40
41	34,77	21,73	34,67	21,88	34,58	22,03	34,48	22,18	34,39	22,33	34,29	22,48	34,19	22,63	34,09	22,78	41
42	35,62	22,26	35,52	22,41	35,42	22,57	35,32	22,72	35,22	22,88	35,12	23,03	35,02	23,18	34,92	23,34	42
43	36,47	22,79	36,37	22,95	36,26	23,10	36,16	23,26	36,06	23,42	35,96	23,58	35,86	23,73	35,75	23,89	43
44	37,32	23,32	37,21	23,48	37,11	23,64	37,01	23,80	36,90	23,97	36,80	24,12	36,69	24,29	36,58	24,45	44
45	38,16	23,85	38,06	24,01	37,95	24,18	37,85	24,34	37,74	24,51	37,63	24,67	37,53	24,84	37,41	25,00	45
46	39,01	24,38	38,90	24,55	38,79	24,71	38,69	24,88	38,58	25,06	38,47	25,22	38,36	25,39	38,25	25,56	46
47	39,86	24,91	39,75	25,08	39,64	25,25	39,53	25,43	39,42	25,60	39,30	25,77	39,19	25,94	39,08	26,12	47
48	40,71	25,44	40,60	25,62	40,48	25,79	40,37	25,97	40,26	26,15	40,14	26,32	40,03	26,49	39,91	26,67	48
49	41,55	25,97	41,44	26,15	41,32	26,32	41,21	26,51	41,10	26,69	40,98	26,86	40,86	27,05	40,74	27,23	49
50	42,40	26,50	42,29	26,68	42,17	26,80	42,05	27,05	41,93	27,23	41,81	27,41	41,69	27,60	41,57	27,78	50
51	43,25	27,03	43,13	27,21</													

Distance	32 Degrees								33 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	51,73	32,32	51,59	32,55	51,45	32,77	51,30	33,00	51,16	33,22	51,01	33,44	50,87	33,67	50,72	33,89	61
62	52,58	32,85	52,44	33,08	52,29	33,31	52,14	33,54	52,00	33,77	51,85	33,98	51,70	34,22	51,55	34,45	62
63	53,42	33,38	53,28	33,62	53,13	33,85	52,98	34,08	52,84	34,31	52,68	34,53	52,53	34,77	52,38	35,00	63
64	54,27	33,91	54,13	34,15	53,97	34,39	53,83	34,62	53,68	34,86	53,52	35,08	53,37	35,32	53,21	35,56	64
65	55,12	34,44	54,97	34,69	54,82	34,92	54,67	35,16	54,51	35,40	54,36	35,63	54,20	35,88	54,04	36,11	65
66	55,97	34,97	55,82	35,22	55,66	35,46	55,51	35,71	55,35	35,95	55,19	36,17	55,04	36,43	54,87	36,67	66
67	56,81	35,50	56,67	35,75	56,50	35,99	56,35	36,25	56,19	36,50	56,03	36,72	55,87	36,98	55,71	37,23	67
68	57,66	36,03	57,51	36,29	57,35	36,53	57,19	36,79	57,03	37,04	56,86	37,27	56,70	37,53	56,54	37,78	68
69	58,51	36,56	58,36	36,82	58,19	37,07	58,03	37,33	57,87	37,58	57,70	37,82	57,54	38,08	57,37	38,34	69
70	59,36	37,09	59,20	37,35	59,04	37,61	58,87	37,87	58,71	38,12	58,54	38,38	58,37	38,64	58,20	38,89	70
71	60,21	37,62	60,05	37,89	59,88	38,15	59,71	38,41	59,55	38,67	59,38	38,93	59,21	39,19	59,03	39,45	71
72	61,06	38,15	60,89	38,42	60,72	38,68	60,55	38,95	60,38	39,21	60,21	39,48	60,04	39,74	59,87	40,00	72
73	61,91	38,68	61,74	38,95	61,57	39,22	61,40	39,49	61,22	39,76	61,05	40,02	60,87	40,29	60,70	40,56	73
74	62,76	39,21	62,58	39,49	62,41	39,76	62,24	40,03	62,06	40,30	61,88	40,57	61,71	40,84	61,53	41,11	74
75	63,60	39,74	63,43	40,02	63,25	40,30	63,08	40,57	62,90	40,85	62,72	41,12	62,54	41,40	62,38	41,67	75
76	64,45	40,27	64,28	40,56	64,09	40,83	63,92	41,11	63,74	41,40	63,56	41,67	63,38	41,95	63,21	42,23	76
77	65,30	40,80	65,12	41,09	64,94	41,37	64,76	41,65	64,58	41,94	64,39	42,22	64,21	42,50	64,04	42,78	77
78	66,15	41,33	65,97	41,62	65,78	41,91	65,60	42,20	65,42	42,48	65,23	42,76	65,04	43,05	64,87	43,34	78
79	67,00	41,86	66,81	42,16	66,62	42,44	66,44	42,74	66,26	43,03	66,06	43,33	65,88	43,60	65,70	43,89	79
80	67,84	42,39	67,66	42,69	67,47	42,98	67,28	43,28	67,09	43,57	66,90	43,86	66,71	44,15	66,52	44,45	80
81	68,69	42,92	68,50	43,22	68,31	43,51	68,12	43,82	67,93	44,12	67,74	44,41	67,54	44,71	67,35	45,00	81
82	69,54	43,45	69,35	43,76	69,16	44,06	68,96	44,36	68,77	44,66	68,57	44,96	68,38	45,26	68,18	45,56	82
83	70,39	43,98	70,20	44,29	70,00	44,59	69,81	44,90	69,61	45,21	69,41	45,51	69,21	45,81	69,01	46,11	83
84	71,24	44,51	71,04	44,82	70,84	45,13	70,65	45,44	70,45	45,75	70,25	46,05	70,05	46,36	69,84	46,67	84
85	72,08	45,04	71,89	45,36	71,69	45,67	71,53	45,98	71,29	46,30	71,08	46,60	70,88	46,91	70,67	47,23	85
86	72,93	45,57	72,73	45,89	72,53	46,21	72,37	46,52	72,12	46,84	71,92	47,15	71,77	47,47	71,50	47,78	86
87	73,78	46,10	73,58	46,43	73,37	46,74	73,21	47,06	72,96	47,39	72,85	47,70	72,55	48,02	72,34	48,34	87
88	74,63	46,63	74,43	46,96	74,21	47,28	74,05	47,61	73,80	47,93	73,69	48,25	73,38	48,57	73,17	48,89	88
89	75,48	47,16	75,27	47,49	75,06	47,82	74,89	48,15	74,64	48,48	74,53	48,79	74,22	49,12	73,99	49,55	89
90	76,32	47,69	76,12	48,02	75,90	48,36	75,69	48,69	75,48	49,02	75,27	49,35	75,05	49,67	74,83	50,00	90
91	77,17	48,22	76,95	48,56	76,75	48,89	76,53	49,23	76,32	49,56	76,10	49,89	75,88	50,22	75,66	50,56	91
92	78,02	48,75	77,86	49,09	77,59	49,43	77,38	49,77	77,16	50,11	76,94	50,44	76,72	50,78	76,49	51,11	92
93	78,87	49,28	78,65	49,63	78,43	49,97	78,22	50,31	78,00	50,65	77,77	50,99	77,55	51,33	77,33	51,67	93
94	79,72	49,81	79,40	50,16	79,28	50,50	79,06	50,85	78,84	51,20	78,61	51,54	78,39	51,88	78,18	52,22	94
95	80,56	50,34	80,35	50,69	80,12	51,04	79,90	51,39	79,67	51,74	79,45	52,09	79,22	52,43	79,01	52,78	95
96	81,41	50,87	81,19	51,23	80,96	51,58	80,74	51,93	80,51	52,39	80,28	52,63	80,05	52,99	79,84	53,34	96
97	82,26	51,40	82,04	51,76	81,81	52,12	81,58	52,47	81,35	52,83	81,12	53,18	80,89	53,54	80,67	53,89	97
98	83,11	51,93	82,88	52,30	82,65	52,65	82,42	53,01	82,19	53,38	81,95	53,73	81,72	54,09	81,50	54,45	98
99	83,96	52,46	83,73	52,83	83,49	53,19	83,26	53,56	83,03	53,92	82,79	54,28	82,56	54,64	82,33	55,00	99
100	84,80	52,99	84,57	53,36	84,34	53,73	84,10	54,09	83,87	54,46	83,63	54,83	83,39	55,19	83,15	55,56	100
101	85,65	53,52	85,42	53,89	85,18	54,27	84,94	54,64	84,71	55,01	84,46	55,38	84,22	55,75	84,00	56,11	101
102	86,50	54,05	86,26	54,43	86,02	54,80	85,79	55,18	85,54	55,55	85,30	55,92	85,06	56,30	84,83	56,67	102
103	87,35	54,58	87,11	54,96	86,87	55,34	86,63	55,72	86,38	56,10	86,14	56,47	85,89	56,85	85,66	57,22	103
104	88,20	55,11	87,96	55,49	87,70	55,88	87,47	56,26	87,22	56,64	86,97	57,02	86,72	57,40	86,49	57,78	104
105	89,04	55,64	88,80	56,03	88,55	56,41	88,31	56,80	88,06	57,19	87,86	57,57	87,56	57,95	87,34	58,34	105
106	89,89	56,17	89,65	56,56	89,40	56,95	89,15	57,34	88,90	57,73	88,64	58,12	88,39	58,51	88,17	58,89	106
107	90,74	56,70	90,49	57,10	90,24	57,49	89,99	57,88	89,74	58,28	89,48	58,66	89,23	59,06	89,0		

Distance	34 Degrees								35 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,83	0,56	0,83	0,56	0,82	0,57	0,82	0,57	0,82	0,57	0,82	0,58	0,81	0,58	0,81	0,58	1
2	1,66	1,12	1,65	1,13	1,65	1,13	1,64	1,14	1,64	1,15	1,63	1,15	1,63	1,16	1,62	1,17	2
3	2,49	1,69	2,47	1,69	2,47	1,70	2,46	1,71	2,46	1,72	2,45	1,73	2,44	1,74	2,43	1,75	3
4	3,32	2,25	3,30	2,25	3,30	2,27	3,29	2,28	3,28	2,29	3,27	2,30	3,26	2,32	3,25	2,34	4
5	4,15	2,81	4,13	2,81	4,12	2,83	4,11	2,85	4,10	2,87	4,08	2,89	4,07	2,90	4,06	2,92	5
6	4,97	3,36	4,96	3,38	4,94	3,40	4,93	3,42	4,91	3,44	4,90	3,46	4,88	3,48	4,87	3,51	6
7	5,80	3,91	5,79	3,94	5,77	3,96	5,75	3,99	5,73	4,01	5,72	4,04	5,69	4,06	5,68	4,09	7
8	6,63	4,47	6,61	4,50	6,59	4,53	6,57	4,56	6,55	4,59	6,53	4,62	6,51	4,65	6,49	4,67	8
9	7,46	5,03	7,44	5,06	7,42	5,10	7,39	5,13	7,37	5,16	7,35	5,19	7,33	5,23	7,30	5,26	9
10	8,29	5,59	8,27	5,63	8,24	5,66	8,22	5,70	8,19	5,74	8,17	5,77	8,14	5,81	8,12	5,84	10
11	9,12	6,15	9,09	6,19	9,06	6,23	9,04	6,27	9,01	6,31	8,98	6,34	8,95	6,39	8,93	6,43	11
12	9,95	6,71	9,92	6,75	9,89	6,80	9,86	6,84	9,83	6,88	9,80	6,93	9,77	6,97	9,74	7,01	12
13	10,78	7,27	10,75	7,32	10,71	7,36	10,68	7,41	10,65	7,46	10,62	7,50	10,58	7,55	10,55	7,59	13
14	11,61	7,83	11,57	7,88	11,54	7,93	11,50	7,98	11,47	8,03	11,43	8,08	11,40	8,13	11,36	8,18	14
15	12,44	8,39	12,40	8,44	12,36	8,49	12,33	8,55	12,29	8,60	12,25	8,66	12,21	8,71	12,17	8,76	15
16	13,26	8,95	13,23	9,01	13,19	9,06	13,1	9,12	13,11	9,18	13,07	9,23	13,02	9,21	12,99	9,35	16
17	14,09	9,51	14,05	9,57	14,01	9,63	13,98	9,69	13,92	9,75	13,88	9,81	13,84	9,87	13,80	9,93	17
18	14,92	10,06	14,88	10,13	14,83	10,19	14,79	10,26	14,74	10,33	14,70	10,39	14,65	10,45	14,61	10,51	18
19	15,75	10,62	15,71	10,69	15,66	10,76	15,61	10,83	15,56	10,90	15,52	10,94	15,47	11,03	15,42	11,10	19
20	16,58	11,18	16,53	11,26	16,48	11,33	16,43	11,40	16,38	11,47	16,33	11,54	16,28	11,61	16,23	11,68	20
21	17,41	11,74	17,36	11,82	17,31	11,89	17,25	11,97	17,20	12,05	17,15	12,12	17,10	12,19	17,04	12,27	21
22	18,24	12,30	18,19	12,38	18,13	12,46	18,08	12,54	18,02	12,62	17,98	12,70	17,91	12,78	17,85	12,85	22
23	19,07	12,86	19,01	12,95	18,95	13,03	18,90	13,11	18,84	13,19	18,78	13,27	18,52	13,36	18,67	13,44	23
24	19,90	13,42	19,84	13,51	19,78	13,59	19,72	13,68	19,66	13,77	19,60	13,85	19,34	13,94	19,48	14,02	24
25	20,73	13,98	20,67	14,08	20,60	14,16	20,54	14,25	20,48	14,34	20,41	14,43	20,15	14,52	20,29	14,60	25
26	21,56	14,54	21,49	14,64	21,43	14,72	21,36	14,82	21,30	14,92	21,23	15,00	20,97	15,10	21,10	15,19	26
27	22,38	15,10	22,32	15,20	22,25	15,29	22,19	15,39	22,12	15,49	22,05	15,58	21,78	15,68	21,91	15,77	27
28	23,21	15,66	23,15	15,77	23,07	15,86	23,01	15,96	22,93	16,06	22,87	16,17	22,59	16,26	22,73	16,36	28
29	24,04	16,22	23,97	16,33	23,90	16,42	23,83	16,53	23,75	16,64	23,69	16,75	23,41	16,84	23,54	16,94	29
30	24,87	16,78	24,80	16,88	24,72	16,99	24,65	17,10	24,57	17,21	24,55	17,31	24,42	17,42	24,35	17,53	30
31	25,70	17,33	25,62	17,45	25,55	17,56	25,47	17,67	25,39	17,78	25,32	17,89	25,24	18,00	25,16	18,11	31
32	26,53	17,89	26,45	18,01	26,37	18,12	26,29	18,24	26,2	18,35	26,13	18,47	26,05	18,58	25,97	18,70	32
33	27,36	18,45	27,28	18,57	27,20	18,69	27,12	18,81	27,03	18,93	26,95	19,05	26,87	19,16	26,78	19,28	33
34	28,19	19,01	28,11	19,14	28,02	19,20	27,94	19,38	27,85	19,50	27,77	19,62	27,68	19,74	27,59	19,86	34
35	29,02	19,57	28,93	19,70	28,84	19,82	28,76	19,95	28,67	20,08	28,58	20,20	28,49	20,33	28,41	20,45	35
36	29,84	20,13	29,76	20,26	29,67	20,39	29,58	20,52	29,49	20,65	29,40	20,78	29,31	20,91	29,22	21,03	36
37	30,67	20,69	30,59	20,82	30,49	20,95	30,40	21,09	30,31	21,22	30,22	21,35	30,12	21,49	30,03	21,62	37
38	31,50	21,25	31,41	21,39	31,32	21,52	31,23	21,66	31,13	21,80	31,03	21,93	30,94	22,07	30,84	22,20	38
39	32,33	21,81	32,24	21,95	32,14	22,09	32,05	22,23	31,95	22,51	31,85	22,51	31,75	22,65	31,65	22,78	39
40	33,16	22,37	33,06	22,51	32,96	22,60	32,87	22,80	32,77	22,94	32,67	23,09	32,56	23,23	32,46	23,37	40
41	33,99	22,93	33,89	23,07	33,79	23,22	33,69	23,37	33,58	23,52	33,48	23,66	33,38	23,81	33,27	23,95	41
42	34,82	23,49	34,72	23,64	34,61	23,79	34,51	23,94	34,40	24,09	34,30	24,24	34,19	24,39	34,09	24,54	42
43	35,65	24,04	35,54	24,20	35,44	24,35	35,33	24,51	35,22	24,60	35,12	24,82	35,01	24,97	34,90	25,12	43
44	36,48	24,60	36,37	24,76	36,26	24,92	36,15	25,08	36,04	25,24	35,93	25,35	35,82	25,55	35,71	25,71	44
45	37,31	25,16	37,20	25,33	37,08	25,49	36,98	25,65	36,86	25,81	36,75	25,97	36,63	26,13	36,52	26,29	45
46	38,14	25,72	38,03	25,89	37,91	26,05	37,80	26,22	37,68	26,39	37,57	26,55	37,45	26,71	37,33	26,87	46
47	38,96	26,28	38,85	26,45	38,73	26,62	38,62	26,79	38,50	26,96	38,38	27,12	38,26	27,29	38,15	27,46	47
48	39,79	26,84	39,68	27,02	39,56	27,18	39,44	27,36	39,32	27,53	39,20	27,70	39,07	27,88	38,96	28,04	48
49	40,62	27,40	40,51	27,58	40,39	27,75	40,26	27,93	40,14	28,11	40,02	28,28	39,89	28,46	39,77	28,63	49
50	41,45	27,96	41,33	28,14	41,21	28,32	41,08	28,50	40,96	28,68	40,83	28,86	40,71	29,03	40,58	29,21	50
51	42,28	28,52	42,16	28,70	42,03	28,89	41,90	29,07	41,78	29,25	41,65	29,93	41,52	29,62	41,39	29,80	51
52	43,11	29,08	42,98	29,27	42,85	29,45	42,73	29,64	42,60	29,83	42,47	30,01	42,33	30,20	42,20	30,38	52
53	43,94	29,64	43,81	29,83	43,68	30,02	43,55	30,21	43,41	30,40	43,28	30,59	43,15	30,78	43,01	30,96	53
54	44,77	30,20	44,64	30,39	44,50	30,58	44,37	30,78	44,23	30,97	44,10	31,17	43,96	31,36	43,83	31,55	54
55	45,60	30,75	45,46	30,95	45,33	31,15	45,19	31,35	45,05	31,55	44,92	31,74	44,78	31,94	44,64	32,13	55
56	46,43	31,31	46,29	31,52	46,15	31,72	46,01	31,92	45,87	32,12	45,73	32,32	45,59	32,52	45,45	32,72	56
57	47,25	31,87	47,12	32,08	46,97	32,28	46,84	32,49	46,69	32,70	46,55	32,90	46,40	33,10	46,26	33,60	57
58	48,08	32,43	47,95	32,64	47,80	32,85	47,66	33,06	47,51	33,27	47,37	33,47	47,22	33,68	47,07	34,18	58
59	48,91	32,99	48,77	33,30	48,62	33,41	48,48	33,63	48,33	33,84	48,18	34,95	48,03	34,26	47,89	34,77	59
60	49,74	33,55	49,59	33,77	49,45	33,98	49,30	34,20	49,15	34,41	49,00	34,63	48,85	34,84	48,69	35,05	60
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	56 Degrees				55 Degrees				54 Degrees								

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Distance	34 Degrees								35 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	50,57	34,11	50,42	34,33	50,27	34,55	50,12	34,77	49,97	34,99	49,81	35,21	49,66	35,42	49,51	35,64	61
62	51,40	34,67	51,25	34,89	51,10	35,12	50,94	35,34	50,79	35,56	50,63	35,78	50,47	36,00	50,32	36,22	62
63	52,23	35,23	52,08	35,46	51,92	35,68	51,76	35,91	51,61	36,14	51,45	36,37	51,29	36,58	51,13	36,81	63
64	53,06	35,79	52,90	36,02	52,74	36,25	52,59	36,48	52,42	36,71	52,27	36,94	52,10	37,17	51,94	37,39	64
65	53,89	36,35	53,73	36,58	53,51	36,81	53,41	37,05	53,24	37,28	53,07	37,51	52,92	37,75	52,75	37,98	65
66	54,72	36,90	54,56	37,13	54,39	37,38	54,23	37,62	54,06	37,86	53,90	38,09	53,73	38,33	53,56	38,56	66
67	55,54	37,46	55,38	37,71	55,22	37,95	55,05	38,19	54,88	38,43	54,72	38,67	54,54	38,91	54,38	39,14	67
68	56,37	38,02	56,21	38,27	56,04	38,51	55,87	38,76	55,70	39,01	55,53	39,24	55,36	39,49	55,19	39,73	68
69	57,20	38,58	57,04	38,83	56,86	39,08	56,70	39,33	56,52	39,58	56,35	39,82	56,17	40,07	56,00	40,31	69
70	58,03	39,14	57,86	39,40	57,69	39,65	57,52	39,90	57,34	40,15	57,16	40,40	56,99	40,65	56,81	40,89	70
71	58,80	39,70	58,69	39,96	58,51	40,21	58,34	40,47	58,16	40,72	57,98	40,98	57,80	41,23	57,62	41,48	71
72	59,69	40,26	59,51	40,52	59,34	40,78	59,16	41,04	58,98	41,30	58,80	41,55	58,62	41,81	58,43	42,07	72
73	60,52	40,82	60,34	41,08	60,16	41,35	59,98	41,61	59,80	41,87	59,61	42,13	59,43	42,39	59,25	42,65	73
74	61,35	41,38	61,17	41,65	60,98	41,91	60,80	42,18	60,62	42,45	60,43	42,71	60,24	42,97	60,06	43,23	74
75	62,18	41,94	62,00	42,21	61,81	42,48	61,63	42,75	61,44	43,02	61,25	43,29	61,06	43,55	60,87	43,82	75
76	63,01	42,50	62,80	42,77	62,63	43,04	62,45	43,32	62,25	43,59	62,07	43,86	61,87	44,13	61,68	44,40	76
77	63,84	43,06	63,65	43,34	63,46	43,61	63,27	43,89	63,07	44,17	62,88	44,44	62,69	44,72	62,49	44,99	77
78	64,66	43,61	64,48	43,90	64,28	44,18	64,09	44,46	63,89	44,74	63,70	45,02	63,50	45,30	63,31	45,57	78
79	65,49	44,17	65,30	44,46	65,10	44,74	64,91	45,03	64,71	45,32	64,52	45,59	64,31	45,88	64,12	46,15	79
80	66,32	44,73	66,13	45,02	65,93	45,31	65,73	45,60	65,53	45,89	65,33	46,17	65,13	46,46	64,93	46,74	80
81	67,15	45,29	66,95	45,59	66,75	45,88	66,54	46,17	66,33	46,46	66,13	46,74	65,94	47,04	65,74	47,32	81
82	67,98	45,85	67,78	46,15	67,58	46,44	67,38	46,74	67,17	47,03	66,96	47,32	66,76	47,62	66,55	47,91	82
83	68,81	46,41	68,61	46,71	68,40	47,01	68,20	47,31	67,99	47,61	67,78	47,90	67,57	48,20	67,36	48,49	83
84	69,64	46,97	69,43	47,28	69,23	47,58	69,09	47,88	68,81	48,18	68,60	48,47	68,39	48,78	68,17	49,08	84
85	70,47	47,53	70,26	47,84	70,05	48,14	69,84	48,45	69,63	48,76	69,42	49,05	69,20	49,36	68,99	49,66	85
86	71,30	48,09	71,09	48,40	70,87	48,71	70,66	49,02	70,45	49,33	70,23	49,63	70,01	49,94	69,80	50,24	86
87	72,13	48,65	71,92	48,96	71,70	49,27	71,49	49,59	71,26	49,90	71,05	50,20	70,83	50,52	70,61	50,83	87
88	72,95	49,21	72,74	49,53	72,52	49,84	72,31	50,16	72,08	50,48	71,87	50,78	71,64	51,10	71,42	51,41	88
89	73,78	49,77	73,57	50,09	73,35	50,41	73,13	50,73	72,90	51,05	72,68	51,36	72,46	51,68	72,23	52,00	89
90	74,61	50,33	74,39	50,65	74,17	50,98	73,95	51,30	73,72	51,62	73,50	51,94	73,27	52,26	73,04	52,58	90
91	75,44	50,89	75,22	51,21	75,00	51,54	74,77	51,87	74,54	52,20	74,31	52,52	74,08	52,84	73,85	53,17	91
92	76,27	51,44	76,05	51,78	75,82	52,11	75,59	52,44	75,36	52,77	75,13	53,10	74,90	53,42	74,67	53,75	92
93	77,10	51,00	76,87	52,34	76,64	52,67	76,41	53,01	76,18	53,34	75,93	53,67	75,71	54,01	75,48	54,34	93
94	77,93	51,56	77,70	52,90	77,47	53,24	77,24	53,58	77,00	53,94	76,77	54,23	76,53	54,59	76,29	54,92	94
95	78,76	52,12	78,53	53,47	78,29	53,81	78,06	54,15	77,82	54,49	77,58	54,83	77,34	55,17	77,10	55,50	95
96	79,59	52,68	79,35	54,03	79,12	54,37	78,88	54,72	78,64	55,07	78,40	55,41	78,15	55,75	77,91	56,09	96
97	80,42	53,24	80,18	54,59	79,94	54,94	79,70	55,29	79,46	55,64	79,22	55,98	78,97	56,33	78,72	56,67	97
98	81,25	54,80	81,01	55,15	80,76	55,56	80,50	55,86	80,28	56,21	80,03	56,56	79,78	56,91	79,53	57,26	98
99	82,07	55,36	81,84	55,72	81,59	56,07	81,35	56,43	81,10	56,79	80,85	57,14	80,60	57,49	80,35	57,84	99
100	82,90	55,92	82,66	56,28	82,41	56,64	82,16	57,00	81,91	57,36	81,66	57,71	81,41	58,07	81,16	58,43	100
101	83,73	56,48	83,49	56,84	83,24	57,21	82,99	57,57	82,73	57,93	82,48	58,29	82,23	58,65	81,97	59,01	101
102	84,56	57,03	84,31	57,41	84,06	57,77	83,81	58,14	83,55	58,49	83,30	58,87	83,04	59,23	82,78	59,59	102
103	85,39	57,59	85,14	57,97	84,88	58,34	84,63	58,71	84,37	59,06	84,11	59,43	83,85	59,81	83,59	60,18	103
104	86,22	58,14	85,97	58,53	85,71	58,91	85,45	59,28	85,19	59,63	84,93	60,02	84,67	60,39	84,41	60,76	104
105	87,05	58,70	86,79	59,09	86,53	59,47	86,27	59,85	86,01	60,21	85,75	60,60	85,48	60,97	85,29	61,35	105
106	87,88	59,26	87,62	59,66	87,36	60,04	87,10	60,42	86,83	60,78	86,57	61,18	86,30	61,56	86,08	61,93	106
107	88,73	59,82	88,45	60,22	88,18	60,60	87,92	60,99	87,65	61,36	87,38	61,75	87,11	62,14	86,90	62,51	107
108	89,56	60,38	89,27	60,78	89,00	61,17	88,74	61,56	88,47	61,93	88,20	62,33	87,92	62,72	87,71	63,10	108
109	90,38	60,94	90,10	61,35	89,83	61,74	89,56	62,13	89,29	62,50	89,02	62,91	88,74	63,30	88,53	63,68	109
110	91,19	61,51	90,92	61,91	90,65	62,30	90,38	62,70	90,11	63,09	89,83	63,49	89,55	63,88	89,27	64,27	110
111	92,02	62,07	91,75	62,47	91,48	62,87	91,20	63,27	90,93	63,67	90,65	64,06	90,37	64,46	90,08	64,85	111
112	92,85	62,63	92,58	63,03	92,30	63,44	92,03	63,84	91,74	64,24	91,46	64,64	91,18	65,04	90,90	65,44	112
113	93,68	63,19	93,41	63,60	93,13	64,00	92,85	64,45	92,56	64,82	92,28	65,22	91,99	65,62	91,71	66,02	113
114	94,51	63,75	94,23	64,16	93,95	64,57	93,67	64,98	93,38	65,39	93,10	65,79	92,81	66,20	92,52	66,60	114
115	95,34	64,31	95,06	64,72	94,77	65,15	94,49	65,55	94,20	65,06	93,91	66,37	93,62	66,78	93,33	67,19	115
116	96,17	64,86	95,89	65,29	95,60	65,71	95,31	66,12	95,02	66,54	94,73	66,95	94,44	67,35	94,15	67,77	116
117	96,99	65,42	96,71	65,85	96,42	66,28	96,14	66,69	95,84	67,11	95,55	67,53	95,25	67,94	94,96	68,36	117
118	97,83	65,98	97,54	66,41	97,25	66,84	96,96	67,26	96,66	67,69	96,37	68,10	96,06	68,52	95,77	68,94	118
119	98,65	66,54	98,37	66,97	98,07	67,41	97,78	67,83	97,48	68,26	97,18	68,68	96,88	69,11	96,58	69,52	119
120	99,48	67,10	99,19	67,54	98,90	67,97	98,60	68,40	98,30	68,83	98,00	69,26	97,69	69,68	97,39	70,11	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	56 Degrees				55 Degrees				54 Degrees								

Distance	36 Degrees								37 Degrees								Distance							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.									
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.								
1	0,81	0,59	0,81	0,59	0,80	0,59	0,81	0,60	0,80	0,60	0,80	0,60	0,79	0,61	0,79	0,61	1							
2	1,62	1,18	1,61	1,18	1,61	1,19	1,60	1,20	1,60	1,20	1,59	1,21	1,59	1,22	1,58	1,22	2							
3	2,43	1,76	2,42	1,77	2,41	1,78	2,40	1,79	2,40	1,80	2,39	1,81	2,38	1,83	2,37	1,84	3							
4	3,24	2,35	3,23	2,36	3,21	2,38	3,20	2,39	3,20	2,41	3,18	2,42	3,17	2,43	3,16	2,45	4							
5	4,04	2,94	4,03	2,96	4,02	2,97	4,01	2,99	3,99	3,01	3,98	3,03	3,97	3,04	3,95	3,06	5							
6	4,85	3,53	4,84	3,55	4,82	3,57	4,81	3,59	4,79	3,61	4,78	3,63	4,76	3,65	4,74	3,67	6							
7	5,66	4,11	5,64	4,14	5,63	4,16	5,61	4,19	5,59	4,21	5,57	4,24	5,55	4,26	5,53	4,29	7							
8	6,47	4,70	6,45	4,73	6,43	4,76	6,41	4,79	6,39	4,81	6,37	4,84	6,35	4,87	6,33	4,90	8							
9	7,28	5,29	7,26	5,32	7,23	5,35	7,21	5,38	7,19	5,42	7,16	5,45	7,14	5,48	7,12	5,51	9							
10	8,09	5,88	8,06	5,91	8,04	5,95	8,01	5,98	7,99	6,02	7,96	6,05	7,93	6,09	7,91	6,12	10							
11	8,90	6,46	8,87	6,50	8,84	6,54	8,81	6,58	8,78	6,62	8,76	6,66	8,73	6,70	8,70	6,73	11							
12	9,71	7,05	9,68	7,10	9,65	7,14	9,61	7,18	9,58	7,22	9,55	7,26	9,52	7,30	9,49	7,35	12							
13	10,52	7,64	10,48	7,69	10,45	7,73	10,43	7,78	10,38	7,82	10,35	7,87	10,31	8,91	10,28	7,96	13							
14	11,33	8,23	11,29	8,28	11,25	8,33	11,21	8,37	11,18	8,43	11,14	8,47	11,11	8,52	11,07	8,57	14							
15	12,13	8,82	12,09	8,87	12,06	8,93	12,01	8,96	11,98	9,03	11,94	9,08	11,90	9,13	11,86	9,18	15							
16	12,94	9,40	12,90	9,46	12,86	9,52	12,82	9,56	12,77	9,63	12,74	9,68	12,69	9,74	12,65	9,79	16							
17	13,75	9,99	13,71	10,0	13,67	10,11	13,62	10,16	13,57	10,23	13,53	10,29	13,48	10,35	13,44	10,41	17							
18	14,56	10,58	14,51	10,64	14,47	10,71	14,42	10,76	14,37	10,83	14,33	10,89	14,28	11,96	14,23	11,01	18							
19	15,37	11,17	15,32	11,23	15,27	11,30	15,22	11,36	15,17	11,44	15,12	11,50	15,07	11,55	15,02	11,63	19							
20	16,18	11,76	16,13	11,83	16,08	11,90	16,02	11,97	15,97	12,04	15,92	12,11	15,87	12,17	15,81	12,24	20							
21	16,99	12,34	16,93	12,42	16,88	12,49	16,83	12,56	16,77	12,64	16,72	12,71	16,66	12,78	16,60	12,86	21							
22	17,80	12,93	17,74	13,01	17,68	13,09	17,63	13,16	17,57	13,24	17,51	13,31	17,45	13,39	17,40	13,47	22							
23	18,61	13,52	18,55	13,60	18,49	13,68	18,43	13,76	18,37	13,84	18,31	13,92	18,25	14,00	18,19	14,08	23							
24	19,42	14,11	19,35	14,19	19,29	14,28	19,23	14,36	19,17	14,44	19,10	14,58	19,04	14,61	18,98	14,69	24							
25	20,22	14,70	20,16	14,78	20,20	14,87	20,03	14,96	20,97	15,05	19,90	15,13	19,83	15,22	19,77	15,30	25							
26	21,03	15,28	20,96	15,37	20,99	15,47	20,83	15,55	20,77	15,65	20,70	15,74	20,62	15,83	20,6	15,92	26							
27	21,84	15,87	21,77	15,96	21,79	16,06	21,63	16,15	21,57	16,25	21,49	16,34	21,42	16,44	21,35	16,53	27							
28	22,65	16,46	22,58	16,55	22,60	16,66	22,43	16,75	22,26	16,85	22,29	16,95	22,21	17,05	22,14	17,14	28							
29	23,46	17,05	23,38	17,14	23,31	17,25	23,33	17,35	23,16	17,45	23,08	17,55	23,00	17,66	22,93	17,75	29							
30	24,27	17,63	24,19	17,74	24,12	17,84	24,04	17,9	23,96	18,05	23,88	18,16	23,79	18,26	23,72	18,37	30							
31	25,08	18,22	25,00	18,33	24,92	18,44	24,84	18,55	24,76	18,66	24,68	18,76	24,59	18,87	24,51	18,98	31							
32	25,89	18,81	25,80	18,92	25,72	19,03	25,64	19,15	25,56	19,26	25,47	19,37	25,39	19,48	25,30	19,59	32							
33	26,70	19,40	26,61	19,51	26,53	19,63	26,44	19,74	26,36	19,86	26,27	19,97	26,18	20,09	26,09	20,20	33							
34	27,51	19,99	27,42	20,10	27,33	20,22	27,24	20,34	27,15	20,46	27,06	20,58	26,97	20,70	26,88	20,81	34							
35	28,32	20,57	28,22	20,69	28,14	20,82	28,04	20,94	27,95	21,06	27,86	21,18	27,77	21,31	27,68	21,43	35							
36	29,12	21,16	29,03	21,28	28,94	21,41	28,84	21,54	28,75	21,67	28,66	21,79	28,56	21,92	28,47	22,04	36							
37	29,93	21,75	29,83	21,88	29,74	22,01	29,64	22,14	29,55	22,27	29,45	22,39	29,35	22,53	29,26	22,65	37							
38	30,74	22,34	30,64	22,47	30,55	22,60	30,45	22,73	30,35	22,87	30,25	23,00	30,14	23,14	30,05	23,26	38							
39	31,55	22,93	31,45	23,06	31,35	23,20	31,25	23,33	31,15	23,47	31,05	23,60	30,94	23,75	30,84	23,87	39							
40	32,36	23,51	32,26	23,65	32,15	23,79	32,05	23,93	31,95	24,27	31,84	24,21	31,73	24,15	31,63	24,19	40							
41	33,17	24,30	33,06	24,24	32,96	24,35	32,85	24,53	32,74	24,67	32,64	24,82	32,53	24,96	32,42	25,10	41							
42	33,98	24,88	33,87	24,83	33,76	24,98	33,65	25,13	33,54	25,28	33,43	25,41	33,32	25,57	33,21	25,71	42							
43	34,79	25,48	34,68	25,42	34,57	25,58	34,45	25,73	34,34	25,88	34,23	26,03	34,11	26,18	34,00	26,32	43							
44	35,60	26,06	35,48	26,02	35,37	26,17	35,25	26,32	35,14	26,48	35,02	26,63	34,91	26,79	34,79	26,94	44							
45	36,41	26,65	36,29	26,61	36,17	26,97	36,05	26,92	35,94	27,08	35,82	27,24	35,70	27,39	35,58	27,55	45							
46	37,21	27,24	37,09	27,20	36,98	27,36	36,86	27,52	36,74	27,68	36,62	27,84	36,49	28,00	36,37	28,16	46							
47	38,02	27,83	37,90	27,79	37,78	27,96	37,66	28,12	37,54	28,29	37,41	28,45	37,28	28,61	37,16	28,77	47							
48	38,83	28,42	38,71	28,38	38,59	28,55	38,46	28,72	38,34	28,89	38,21	29,03	38,08	29,22	37,96	29,38	48							
49	39,64	29,00	39,51	28,97	39,39	29,15	39,26	29,31	39,14	29,49	39,00	29,66	38,87	29,83	38,75	30,09	49							
50	40,45	29,59	40,32	29,57	40,19	29,74	40,06	29,91	39,93	30,09	39,80	30,26	39,67	30,44	39,53	30,61	50							
51	41,26	30,18	41,13	30,16	41,00	30,34	40,86	30,51	40,73	30,69	40,60	30,87	40,46	31,05	40,33	31,22	51							
52	42,07	30,77	41,93	30,75	41,80	30,93	41,66	31,11	41,52	31,29	41,39	31,47	41,25	31,66	41,12	31,83	52							
53	42,87	31,35	42,74	31,34	42,60	31,53	42,47	31,71	42,32	31,90	42,19	32,08	42,05	32,26	41,91	32,45	53							
54	43,68	31,94	43,55	31,93	43,41	32,12	43,27	32,31	43,12	32,50	42,93	32,68	42,84	32,87	42,70	33,06	54							
55	44,49	32,53	44,35	32,52	44,21	32,72	44,09	32,91	43,92	33,10	43,78	33,29	43,63	33,48	43,49	33,67	55							
56	45,30	33,11	45,16	33,11	45,02	33,32	44,87	33,51	44,72	33,70	44,58	33,89	44,43	34,09	44,28	34,28	56							
57	46,11	33,69	45,96	33,70	45,82	33,91	45,67	34,11	45,51	34,30	45,37	34,50	45,22	34,70	45,07	34,89	57							
58	46,92	34,28	46,77	34,29	46,62	34,50	46,47	34,70	46,31	34,91	46,17	35,10	46,01	35,31	45,86	35,51	58							
59	47,73	34,87	47,58	34,88	47,43	35,10	47,27	35,30	47,11	35,51	46,96	35,71	46,80	35,82	46,69	36,12	59							
60	48,54	35,46	48,39	35,48	48,23	35,69	48,07	35,90	47,92	36,11	47,76	36,32	47,60	36,53	47,44	36,73	60							
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance							
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.									
	54 Degrees								53 Degrees								52 Degrees							

TRAVERSE TABLE, 712.

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Distance	36 Degrees								37 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	49,35	35,85	49,19	36,07	49,04	36,28	48,88	36,50	48,72	36,71	48,56	36,92	48,39	37,13	48,23	37,34	61
62	50,16	36,44	49,99	36,66	49,84	36,88	49,68	37,09	49,52	37,31	49,35	37,53	49,19	37,74	49,02	37,96	62
63	50,97	37,03	50,80	37,25	50,64	37,47	50,48	37,69	50,31	37,91	50,15	38,13	49,98	38,35	49,81	38,57	63
64	51,78	37,62	51,61	37,84	51,45	38,07	51,28	38,29	51,11	38,52	50,94	38,74	50,77	38,96	50,60	39,18	64
65	52,59	38,21	52,42	38,43	52,25	38,66	52,08	38,89	51,91	39,12	51,74	39,34	51,57	39,57	51,40	39,79	65
66	53,39	38,79	53,22	39,02	53,06	39,26	52,88	39,49	52,71	39,72	52,54	39,95	52,36	40,18	52,19	40,40	66
67	54,20	39,38	54,03	39,62	53,86	39,85	53,68	40,08	53,51	40,32	53,33	40,55	53,15	40,79	52,98	41,02	67
68	55,01	39,97	54,83	40,21	54,66	40,45	54,48	40,68	54,31	40,92	54,13	41,16	53,94	41,40	53,77	41,63	68
69	55,82	40,56	55,65	40,80	55,47	41,04	55,28	41,28	55,11	41,53	54,92	41,76	54,74	42,00	54,56	42,24	69
70	56,63	41,14	56,45	41,39	56,27	41,64	56,09	41,88	55,90	42,13	55,72	42,37	55,53	42,61	55,35	42,85	70
71	57,44	41,73	57,26	41,98	57,07	42,22	56,89	42,48	56,70	42,73	56,52	42,97	56,33	43,22	56,14	43,47	71
72	58,25	42,32	58,06	42,57	57,88	42,83	57,69	43,08	57,50	43,33	57,31	43,58	57,14	43,83	56,93	44,08	72
73	59,06	42,91	58,87	43,16	58,68	43,42	58,49	43,68	58,30	43,94	58,11	44,18	57,93	44,44	57,72	44,69	73
74	59,87	43,50	59,67	43,76	59,49	44,02	59,29	44,27	59,10	44,53	58,90	44,79	58,73	45,05	58,51	45,30	74
75	60,68	44,08	60,48	44,35	60,29	44,61	60,09	44,87	59,90	45,14	59,70	45,39	59,52	45,66	59,30	45,91	75
76	61,48	44,67	61,29	44,93	61,09	45,21	60,89	45,48	60,70	45,74	60,49	46,00	60,31	46,27	60,09	46,53	76
77	62,29	45,26	62,09	45,53	61,90	45,8	61,69	46,07	61,51	46,34	61,29	46,60	61,11	46,88	60,88	47,14	77
78	63,10	45,85	62,90	46,12	62,70	46,40	62,50	46,67	62,31	46,94	62,09	47,21	61,90	47,48	61,68	47,75	78
79	63,91	46,44	63,70	46,71	63,57	46,99	63,3	47,26	63,10	47,54	62,88	47,81	62,69	48,09	62,47	48,36	79
80	64,78	47,02	64,51	47,30	64,31	47,59	64,10	47,87	63,89	48,1	63,68	48,42	63,47	48,70	63,25	48,98	80
81	65,53	47,61	65,32	47,90	65,11	48,18	64,90	48,46	64,69	48,75	64,48	49,03	64,20	49,31	64,0	49,59	81
82	66,34	48,20	66,13	48,49	65,92	48,78	65,70	49,06	65,49	49,35	65,27	49,63	65,05	49,92	64,84	50,20	82
83	67,15	48,79	66,93	49,08	66,72	49,37	66,50	49,66	66,29	49,95	66,07	50,24	65,85	50,53	65,63	50,81	83
84	67,96	49,37	67,74	49,67	67,52	49,97	67,30	50,26	67,09	50,55	66,86	50,84	66,64	51,14	66,42	51,43	84
85	68,77	49,96	68,54	50,26	68,33	50,56	68,10	50,86	67,89	51,16	67,66	51,45	67,43	51,75	67,21	52,04	85
86	69,57	50,55	69,35	50,85	69,13	51,16	68,91	51,45	68,68	51,76	68,46	52,05	68,23	52,3	68,00	52,65	86
87	70,38	51,14	70,16	51,44	69,94	51,75	69,71	52,05	69,48	52,36	69,25	52,66	69,02	52,96	68,79	53,26	87
88	71,19	51,73	70,96	52,03	70,74	52,35	70,51	52,66	70,28	52,96	70,05	53,26	69,81	53,57	69,58	53,87	88
89	72,00	52,31	71,77	52,62	71,54	52,95	71,31	53,26	71,08	53,56	70,84	53,87	70,60	54,18	70,37	54,49	89
90	72,81	52,90	72,58	53,22	72,35	53,53	72,11	53,85	71,88	54,16	71,64	54,48	71,40	54,79	71,16	55,10	90
91	73,61	53,49	73,39	53,81	73,15	54,13	72,91	54,45	72,68	54,77	72,44	55,08	72,19	55,40	71,95	55,71	91
92	74,42	54,08	74,19	54,40	73,95	54,72	73,71	55,04	73,48	55,37	73,23	55,69	72,99	56,01	72,74	56,32	92
93	75,23	54,68	74,99	54,99	74,76	55,32	74,52	55,64	74,27	55,97	74,03	56,29	73,78	56,61	73,53	56,94	93
94	76,04	55,25	75,80	55,58	75,56	55,91	75,32	56,24	75,07	56,57	74,82	56,90	74,57	57,22	74,33	57,5	94
95	76,85	55,84	76,61	56,17	76,37	56,51	76,12	56,84	75,87	57,17	75,62	57,50	75,37	57,83	75,12	58,16	95
96	77,66	56,43	77,42	56,76	77,17	57,10	76,92	57,44	76,67	57,78	76,42	58,11	76,16	58,44	75,91	58,77	96
97	78,47	57,02	78,22	57,35	77,97	57,70	77,72	58,03	77,47	58,38	77,21	58,71	76,95	59,05	76,70	59,38	97
98	79,27	57,60	79,03	57,95	78,70	58,29	78,52	58,63	78,27	58,98	78,01	59,32	77,75	59,66	77,49	60,00	98
99	80,08	58,19	79,83	58,54	79,50	58,89	79,32	59,23	79,07	59,58	78,80	59,92	78,54	60,27	78,28	60,61	99
100	80,90	58,78	80,64	59,13	80,39	59,48	80,12	59,83	79,86	60,18	79,60	60,53	79,33	60,88	79,07	61,23	100
101	81,71	59,37	81,55	59,72	81,19	60,08	80,93	60,43	80,66	60,78	80,40	61,13	80,13	61,48	79,86	61,83	101
102	82,52	59,95	82,36	60,31	81,99	60,67	81,73	61,03	81,46	61,39	81,19	61,73	80,92	62,09	80,65	62,45	102
103	83,33	60,54	83,16	60,90	82,80	61,27	82,53	61,63	82,26	61,99	81,99	62,34	81,72	62,70	81,44	63,06	103
104	84,14	61,13	83,97	61,49	83,60	61,86	83,33	62,22	83,06	62,59	82,78	62,9	82,56	63,31	82,23	63,67	104
105	84,95	61,72	84,77	62,09	84,41	62,46	84,13	62,82	83,86	63,19	83,58	63,5	83,39	63,92	83,02	64,28	105
106	85,76	62,31	85,58	62,68	85,21	63,05	84,93	63,42	84,66								

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38 Degrees										39 Degrees										Distance
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.						
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.					
1	0,78	0,62	0,79	0,62	0,78	0,63	0,78	0,63	0,78	0,63	0,77	0,63	0,77	0,64	0,77	0,64	1			
2	1,58	1,23	1,57	1,24	1,57	1,25	1,56	1,25	1,55	1,26	1,55	1,27	1,54	1,27	1,54	1,28	2			
3	2,36	1,85	2,30	1,86	2,35	1,87	2,34	1,88	2,33	1,89	2,32	1,90	2,32	1,91	2,31	1,92	3			
4	3,15	2,46	3,14	2,48	3,13	2,49	3,12	2,50	3,11	2,52	3,10	2,53	3,09	2,54	3,08	2,56	4			
5	3,94	3,08	3,93	3,10	3,91	3,11	3,90	3,13	3,89	3,15	3,87	3,10	3,86	3,13	3,84	3,20	5			
6	4,73	3,69	4,71	3,72	4,70	3,74	4,68	3,76	4,66	3,78	4,65	3,80	4,63	3,82	4,61	3,84	6			
7	5,52	4,31	5,50	4,33	5,48	4,36	5,46	4,38	5,44	4,41	5,42	4,43	5,4	4,45	5,38	4,48	7			
8	6,30	4,93	6,28	4,95	6,26	4,98	6,24	5,01	6,22	5,04	6,20	5,0	6,17	5,09	6,15	5,12	8			
9	7,09	5,54	7,07	5,57	7,04	5,60	7,02	5,63	6,99	5,66	6,97	5,69	6,95	5,73	6,92	5,76	9			
10	7,88	6,16	7,85	6,19	7,83	6,23	7,80	6,26	7,77	6,29	7,74	6,33	7,72	6,36	7,69	6,39	10			
11	8,67	6,77	8,64	6,81	8,61	6,85	8,58	6,89	8,55	6,92	8,52	6,9	8,49	6,99	8,46	7,03	11			
12	9,46	7,39	9,42	7,43	9,39	7,47	9,36	7,51	9,33	7,55	9,29	7,59	9,26	7,63	9,23	7,67	12			
13	10,24	8,00	10,21	8,05	10,17	8,09	10,14	8,14	10,10	8,18	10,07	8,23	10,03	8,27	10,00	8,31	13			
14	11,03	8,62	10,99	8,67	10,96	8,72	10,92	8,76	10,88	8,81	10,84	8,8	10,89	8,91	10,76	8,95	14			
15	11,82	9,24	11,78	9,29	11,74	9,34	11,70	9,39	11,65	9,44	11,62	9,49	11,58	9,54	11,53	9,59	15			
16	12,61	9,85	12,56	9,91	12,52	9,96	12,48	10,02	12,43	10,07	12,39	10,13	12,35	10,18	12,30	10,23	16			
17	13,40	10,47	13,35	10,52	13,31	10,59	13,26	10,6	13,21	10,70	13,16	10,76	13,12	10,81	13,07	10,87	17			
18	14,18	11,08	14,13	11,14	14,9	11,21	14,04	11,27	13,99	11,33	13,94	11,39	13,89	11,45	13,84	11,51	18			
19	14,97	11,70	14,92	11,76	14,87	11,83	14,82	11,89	14,77	11,96	14,71	12,02	14,66	12,09	14,61	12,15	19			
20	15,76	12,31	15,71	12,38	15,65	12,45	15,60	12,52	15,54	12,59	15,49	12,65	15,43	12,72	15,38	12,79	20			
21	16,55	12,93	16,49	13,00	16,44	13,07	16,38	13,14	16,32	13,22	16,26	13,29	16,20	13,36	16,15	13,43	21			
22	17,34	13,55	17,27	13,62	17,22	13,70	17,16	13,77	17,10	13,85	17,04	13,92	16,98	13,99	16,92	14,07	22			
23	18,12	14,16	18,06	14,24	18,00	14,32	17,94	14,40	17,87	14,47	17,81	14,55	17,75	14,63	17,68	14,71	23			
24	18,91	14,78	18,85	14,86	18,78	14,94	18,72	15,02	18,65	15,10	18,58	15,18	18,52	15,26	18,45	15,35	24			
25	19,70	15,39	19,63	15,46	19,57	15,57	19,50	15,65	19,43	15,73	19,36	15,82	19,29	15,90	19,22	15,98	25			
26	20,49	16,01	20,41	16,08	20,35	16,19	20,28	16,27	20,21	16,36	20,13	16,45	20,0	16,53	19,99	16,62	26			
27	21,28	16,63	21,20	16,70	21,13	16,81	21,06	16,90	20,98	16,99	20,91	17,08	21,84	17,17	20,76	17,26	27			
28	22,06	17,24	21,99	17,31	21,92	17,43	21,84	17,53	21,76	17,62	21,69	17,72	22,61	17,81	21,53	17,90	28			
29	22,85	17,86	22,77	17,93	22,70	18,06	22,62	18,15	22,54	18,25	22,46	18,35	23,38	18,44	22,29	18,54	29			
30	23,64	18,47	23,56	18,57	23,48	18,66	23,39	18,78	23,32	18,88	23,23	18,98	23,15	19,08	23,07	19,18	30			
31	24,43	19,89	24,35	19,19	24,26	19,30	24,18	19,4	24,09	19,51	24,01	19,61	23,93	19,72	23,83	19,82	31			
32	25,22	19,7	25,13	19,81	25,04	19,92	24,96	20,03	24,87	20,14	24,78	20,25	24,69	20,35	24,60	20,46	32			
33	26,00	20,32	25,92	20,43	25,83	20,54	25,74	20,66	25,65	20,77	25,55	20,88	25,47	20,99	25,37	21,10	33			
34	26,79	20,93	26,70	21,05	26,61	21,17	26,52	21,28	26,43	21,40	26,33	21,51	26,24	21,63	26,14	21,74	34			
35	27,58	21,55	27,49	21,67	27,39	21,79	27,30	21,91	27,2	22,03	27,10	22,15	27,01	22,26	26,91	22,38	35			
36	28,37	22,17	28,27	22,29	28,18	22,41	28,0	22,53	27,98	22,65	27,88	22,78	27,78	22,90	27,68	23,02	36			
37	29,16	22,78	29,06	22,91	28,96	23,04	28,86	23,16	28,75	23,28	28,65	23,41	28,55	23,53	28,45	23,66	37			
38	29,94	23,4	29,84	23,53	29,74	23,66	29,64	23,79	29,53	23,91	29,42	24,05	29,33	24,17	29,22	24,30	38			
39	30,73	24,01	30,63	24,11	30,53	24,28	30,42	24,41	30,31	24,54	30,20	24,68	30,09	24,81	29,99	24,93	39			
40	31,52	24,63	31,41	24,76	31,30	24,90	31,20	25,04	31,09	25,17	30,98	25,31	30,87	25,44	30,75	25,58	40			
41	32,31	25,24	32,20	25,38	32,09	25,52	31,98	25,66	31,87	25,80	31,75	25,94	31,64	26,08	31,52	26,22	41			
42	33,10	25,86	32,98	26,0	32,87	26,15	32,76	26,29	32,64	26,43	32,52	26,57	32,41	26,72	32,29	26,86	42			
43	33,88	26,47	33,77	26,02	33,65	26,77	33,54	26,92	33,42	27,00	33,30	27,21	33,18	27,35	33,00	27,50	43			
44	34,67	27,09	34,55	27,24	34,44	27,39	34,32	27,54	34,20	27,70	34,07	27,84	33,95	27,99	33,83	28,13	44			
45	35,46	27,71	35,34	27,86	35,22	28,02	35,10	28,17	34,97	28,32	34,85	28,47	34,73	28,62	34,60	28,77	45			
46	36,25	28,32	36,12	28,48	36,00	28,64	35,88	29,79	35,75	28,95	35,62	29,11	35,50	29,26	35,37	29,41	46			
47	37,04	28,94	36,91	29,10	36,78	29,20	36,66	29,42	36,53	29,58	36,39	29,74	36,27	29,9	36,14	30,05	47			
48	37,82	29,55	37,69	29,72	37,57	29,88	37,44	30,05	37,30	30,27	37,17	30,37	37,04	30,53	36,91	30,69	48			
49	38,61	30,17	38,48	30,34	38,35	30,50	38,22	30,67	38,8	30,83	37,94	31,01	37,81	31,17	37,68	31,33	49			
50	39,40	30,78	39,27	30,96	39,13	31,13	38,99	31,30	38,86	31,47	38,72	31,64	30,58	31,80	38,44	31,97	50			
51	40,19	31,40	40,05	31,57	39,91	31,75	39,77	31,92	39,64	32,10	39,49	32,27	39,35	32,44	39,21	32,61	51			
52	40,98	32,02	40,84	32,19	40,70	32,37	40,5	32,55	40,41	32,72	40,27	32,90	40,13	33,08	39,98	33,25	52			
53	41,77	32,63	41,62	32,81	41,48	33,00	41,33	33,17	41,19	33,35	41,04	33,54	40,90	33,71	40,75	33,89	53			
54	42,55	33,25	42,41	33,43	42,26	33,62	42,11	33,80	41,97	33,98	41,82	34,17	41,67	34,34	41,52	34,53	54			
55	43,34	33,86	43,19	34,05	43,05	34,24	42,89	34,43	42,75	34,61	42,59	34,80	42,44	34,98	42,29	35,17	55			
56	44,13	34,48	43,98	34,67	43,83	34,86	43,67	35,05	43,52	35,24	43,36	35,43	43,21	35,62	43,06	35,81	56			
57	44,92	35,10	44,76	35,29	44,61	35,49	44,45	35,68	44,30	35,87	44,15	36,07	43,99	36,26	43,83	36,45	57			
58	45,71	35,71	45,55	35,91	45,39	36,11	45,23	36,30	45,07	36,50	44,93	36,70	44,76	36,89	44,59	37,08	58			
59	46,49	36,33	46,33	36,53	46,18	36,73	46,01	36,93	45,85	37,13	45,70	37,33	45,53	37,53	46,36	37,72	59			
60	47,28	36,94	47,12	37,15	46,96	37,35	46,79	37,56	46,68	37,76	46,40	37,96	46,30	38,1	46,13	38,37	60			
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance			
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.					
	52 Deg.				51 Degrees				50 Degrees											

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Y y 2

40 Degrees										41 Degrees																			
0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.															
Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.														
1	0,77	0,64	0,70	0,65	0,76	0,65	0,76	0,65	0,76	0,66	0,75	0,66	0,75	0,66	0,75	0,67	1												
2	1,53	1,29	1,53	1,29	1,52	1,30	1,52	1,31	1,51	1,31	1,50	1,32	1,50	1,33	1,49	1,33	2												
3	2,30	1,93	2,29	1,94	2,28	1,95	2,27	1,96	2,26	1,97	2,26	1,98	2,25	1,99	2,24	2,00	3												
4	3,06	2,57	3,05	2,58	3,05	2,59	3,03	2,61	3,02	2,62	3,01	2,63	3,00	2,65	2,98	2,66	4												
5	3,83	3,21	3,82	3,23	3,80	3,25	3,78	3,26	3,77	3,28	3,76	3,30	3,75	3,31	3,73	3,33	5												
6	4,60	3,86	4,58	3,88	4,56	3,90	4,55	3,92	4,53	3,94	4,51	3,96	4,49	3,98	4,48	4,00	6												
7	5,36	4,51	5,34	4,52	5,32	4,55	5,30	4,57	5,28	4,59	5,26	4,62	5,24	4,64	5,22	4,66	7												
8	6,13	5,14	6,11	5,17	6,08	5,20	6,06	5,22	6,04	5,25	6,02	5,28	5,99	5,30	5,97	5,33	8												
9	6,89	5,79	6,87	5,81	6,84	5,85	6,82	5,88	6,79	5,91	6,77	5,93	6,74	5,96	6,72	5,99	9												
10	7,66	6,43	7,63	6,46	7,60	6,5	7,58	6,53	7,55	6,56	7,52	6,59	7,49	6,63	7,46	6,66	10												
11	8,43	7,07	8,40	7,11	8,37	7,14	8,33	7,18	8,30	7,22	8,27	7,25	8,24	7,29	8,21	7,33	11												
12	9,19	7,71	9,16	7,75	9,13	7,79	9,09	7,83	9,06	7,87	9,02	7,92	8,99	7,95	8,95	7,99	12												
13	9,96	8,36	9,92	8,40	9,89	8,44	9,85	8,49	9,81	8,53	9,77	8,57	9,74	8,61	9,70	8,66	13												
14	10,72	9,00	10,69	9,05	10,65	9,09	10,61	9,14	10,57	9,18	10,53	9,23	10,49	9,28	10,45	9,32	14												
15	11,49	9,64	11,45	9,69	11,41	9,74	11,37	9,79	11,32	9,84	11,28	9,89	11,24	9,94	11,19	9,99	15												
16	12,26	10,29	12,21	10,34	12,17	10,39	12,12	10,45	12,08	10,50	12,03	10,55	11,98	10,60	11,94	10,66	16												
17	13,2	10,93	12,98	10,98	12,93	11,04	12,88	11,09	12,83	11,15	12,78	11,21	12,73	11,27	12,68	11,32	17												
18	13,79	11,57	13,74	11,63	13,69	11,69	13,64	11,75	13,59	11,81	13,53	11,87	13,48	11,93	13,43	11,99	18												
19	14,55	12,21	14,50	12,28	14,44	12,34	14,40	12,40	14,34	12,46	14,29	12,53	14,23	12,59	14,18	12,65	19												
20	15,32	12,86	15,27	12,92	15,21	12,99	15,15	13,06	15,09	13,12	15,04	13,19	14,98	13,25	14,92	13,32	20												
21	16,09	13,50	16,03	13,57	15,97	13,64	15,91	13,71	15,85	13,78	15,79	13,85	15,73	13,92	15,67	13,98	21												
22	16,85	14,14	16,79	14,21	16,73	14,29	16,67	14,36	16,60	14,43	16,54	14,51	16,48	14,58	16,41	14,65	22												
23	17,62	14,79	17,55	14,86	17,49	14,94	17,43	15,01	17,36	15,09	17,30	15,16	17,23	15,24	17,16	15,32	23												
24	18,39	15,43	18,32	15,51	18,25	15,59	18,18	15,67	18,11	15,75	18,05	15,82	17,98	15,90	17,91	15,98	24												
25	19,1	16,07	19,08	16,15	19,01	16,23	18,94	16,32	18,87	16,39	18,80	16,48	18,73	16,57	18,65	16,65	25												
26	19,92	16,71	19,84	16,80	19,77	16,88	19,70	16,97	19,62	17,05	19,55	17,14	19,47	17,23	19,40	17,31	26												
27	20,68	17,36	20,61	17,44	20,53	17,53	20,46	17,63	20,38	17,70	20,30	17,80	20,22	17,89	20,14	17,98	27												
28	21,45	18,00	21,37	18,09	21,29	18,18	21,22	18,28	21,13	18,36	21,05	18,46	20,97	18,56	20,89	18,65	28												
29	22,22	18,64	22,13	18,74	22,05	18,83	21,97	18,93	21,89	19,02	21,81	19,12	21,72	19,22	21,64	19,31	29												
30	22,98	19,28	22,9	19,38	22,81	19,48	22,73	19,58	22,64	19,68	22,56	19,78	22,47	19,88	22,38	19,98	30												
31	23,75	19,93	23,66	20,03	23,57	20,13	23,49	20,24	23,39	20,34	23,31	20,44	23,22	20,54	23,13	20,64	31												
32	24,51	20,57	24,42	20,68	24,33	20,78	24,24	20,89	24,15	20,99	24,06	21,10	23,97	21,21	23,87	21,31	32												
33	25,28	21,21	25,19	21,32	25,09	21,43	25,00	21,54	24,91	21,65	24,81	21,76	24,72	21,86	24,62	21,97	33												
34	26,05	21,86	25,95	21,97	25,85	22,08	25,76	22,20	25,66	22,31	25,56	22,42	25,47	22,53	25,37	22,64	34												
35	26,81	22,50	26,71	22,61	26,61	22,73	26,52	22,85	26,42	22,96	26,32	23,08	26,21	23,19	26,11	23,31	35												
36	27,58	23,14	27,48	23,26	27,37	23,38	27,28	23,50	27,17	23,62	27,07	23,74	26,96	23,86	26,82	23,97	36												
37	28,34	23,79	28,24	23,91	28,13	24,03	28,03	24,15	27,93	24,37	27,82	24,39	27,71	24,52	27,60	24,64	37												
38	29,11	24,43	29,00	24,55	28,89	24,68	28,79	24,81	28,68	25,03	28,57	25,05	28,46	25,18	28,35	25,31	38												
39	29,88	25,07	29,76	25,19	29,65	25,33	29,55	25,46	29,44	25,69	29,32	25,71	29,21	25,85	29,10	25,97	39												
40	30,64	25,71	30,53	25,85	30,42	25,98	30,30	26,11	30,19	26,24	30,07	26,37	29,96	26,51	29,84	26,64	40												
41	31,41	26,36	31,29	26,49	31,18	26,63	31,06	26,76	30,94	26,90	30,83	27,03	30,71	27,17	30,59	27,30	41												
42	32,17	26,99	32,06	27,14	31,94	27,28	31,82	27,42	31,60	27,55	31,58	27,69	31,46	27,83	31,33	27,97	42												
43	32,94	27,64	32,82	27,78	32,70	27,93	32,58	28,07	32,35	28,21	32,33	28,35	32,20	28,49	32,08	28,63	43												
44	33,71	28,28	33,58	28,43	33,46	28,57	33,34	28,72	33,11	28,87	33,08	29,01	32,94	29,16	32,83	29,30	44												
45	34,47	28,93	34,34	29,08	34,22	29,22	34,09	29,38	33,86	29,52	33,83	29,67	33,69	29,82	33,57	29,97	45												
46	35,24	29,57	35,11	29,71	34,98	29,87	34,85	30,03	34,62	30,18	34,59	30,33	34,44	30,48	34,32	30,63	46												
47	36,00	30,21	35,87	30,37	35,74	30,52	35,61	30,68	35,37	30,83	35,34	30,99	35,19	31,15	35,06	31,30	47												
48	36,77	30,86	36,63	31,01	36,50	31,17	36,37	31,33	36,13	31,49	36,09	31,65	35,94	31,81	35,81	31,96	48												
49	37,54	31,50	37,40	31,66	37,26	31,82	37,13	31,99	36,88	32,15	36,84	32,31	36,69	32,47	36,56	32,63	49												
50	38,30	32,14	38,16	32,31	38,02	32,47	37,88	32,64	37,74	32,80	37,59	32,97	37,45	33,13	37,30	33,29	50												
51	39,07	32,78	38,93	32,95	38,78	33,12	38,64	33,29	38,49	33,46	38,24	33,63	38,20	33,79	38,05	33,96	51												
52	39,83	33,43	39,69	33,6	39,54	33,77	39,40	33,94	39,25	34,12	39,00	34,29	38,95	34,46	38,80	34,63	52												
53	40,60	34,07	40,45	34,24	40,30	34,42	40,15	34,60	40,00	34,77	39,75	34,95	39,70	35,12	39,54	35,29	53												
54	41,37	34,71	41,21	34,89	41,06	35,07	40,91	35,25	40,76	35,43	40,50	35,60	40,44	35,78	40,29	35,96	54												
55	42,13	35,36	41,98	35,54	41,82	35,72	41,67	35,90	41,51	36,08	41,25	36,26	41,19	36,45	41,03	36,62	55												
56	42,90	36,00	42,74	36,18	42,58	36,37	42,43	36,56	42,27	36,74	42,00	36,92	41,94	37,11	41,78	37,29	56												
57	43,66	36,64	43,50	36,83	43,34	37,02	43,19	37,21	42,92	37,40	42,76	37,58	42,69	37,77	42,53	37,96	57												
58	44,43	37,28	44,27	37,47	44,10	37,67	43,95	37,86	43,67	38,05	43,51	38,24	43,44	38,44	43,27	38,62	58												
59	45,20	37,93	45,03	38,12	44,86	38,31	44,70	38,52	44,43	38,71	44,26	38,90	44,19	39,10	44,02	39,29	59												
60	45,96	38,57	45,79	38,77	45,63	38,97	45,45	39,17	45,23	39,36	45,01	39,56	44,94	39,76	44,76	39,95	60												
Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Dep.		Lat.		Dep.													
0 Min.		45 Min.		30 Min.		5		0 Min.		45 Min.		30 Min.		15 Min.															
50 Deg.										49 Degrees										48 Degrees									

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Distance	40 Degrees								41 Degrees								Distance							
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.									
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.								
61	46,73	39,21	46,56	39,41	46,39	39,62	46,21	39,82	46,04	40,02	45,86	40,16	45,69	40,42	45,57	40,62	61							
62	47,49	39,85	47,32	40,06	47,15	40,27	46,97	40,47	46,79	40,68	46,61	40,82	46,44	41,08	46,26	41,29	62							
63	48,26	40,50	48,08	40,71	47,91	40,91	47,73	41,13	47,55	41,33	47,37	41,48	47,19	41,75	47,00	41,95	63							
64	49,03	41,14	48,85	41,35	48,67	41,56	48,49	41,78	48,31	41,99	48,12	42,14	47,93	42,41	47,75	42,62	64							
65	49,79	41,78	49,61	42,00	49,43	42,21	49,24	42,43	49,06	42,64	48,88	42,80	48,68	43,07	48,49	43,28	65							
66	50,56	42,43	50,37	42,64	50,19	42,86	50,00	43,08	49,81	43,30	49,62	43,46	49,48	43,74	49,24	43,95	66							
67	51,32	43,07	51,14	43,29	50,95	43,51	50,76	43,74	50,57	43,96	50,37	44,11	50,18	44,40	49,99	44,62	67							
68	52,09	43,71	51,90	43,94	51,71	44,16	51,52	44,39	51,32	44,61	51,13	44,77	50,93	45,06	50,73	45,28	68							
69	52,86	44,35	52,60	44,58	52,47	44,81	52,28	45,04	52,08	44,27	51,88	45,43	51,60	45,72	51,48	45,96	69							
70	53,62	45,00	53,43	45,23	53,23	45,46	53,04	45,69	52,83	45,93	52,63	46,16	52,43	46,38	52,22	46,61	70							
71	54,39	45,64	54,19	45,87	53,99	46,11	53,79	46,35	53,59	46,58	53,38	46,81	53,18	47,05	52,97	47,28	71							
72	55,16	46,28	54,95	46,52	54,75	46,76	54,55	47,00	54,34	47,24	54,13	47,47	53,93	47,71	53,72	47,94	72							
73	55,92	46,92	55,72	47,17	55,51	47,41	55,30	47,65	55,10	47,89	54,89	48,13	54,67	48,37	54,46	48,61	73							
74	56,69	47,57	56,48	47,81	56,27	48,06	56,06	48,31	55,85	48,55	55,64	48,80	55,42	49,04	55,21	49,28	74							
75	57,46	48,21	57,24	48,46	57,03	48,69	56,82	48,96	56,61	49,20	56,39	49,45	56,17	49,70	55,95	49,94	75							
76	58,22	48,85	58,00	49,10	57,79	49,30	57,58	49,61	57,36	49,86	57,14	50,07	56,92	50,36	56,70	50,51	76							
77	58,99	49,50	58,77	49,75	58,55	49,99	58,34	50,26	58,12	50,52	57,89	50,77	57,67	51,02	57,45	51,17	77							
78	59,75	50,14	59,53	50,40	59,31	50,64	59,09	50,92	58,87	51,17	58,64	51,43	58,42	51,69	58,19	51,84	78							
79	60,52	50,77	60,29	51,04	60,07	51,29	59,85	51,57	59,63	51,83	59,40	52,09	59,17	52,35	58,94	52,51	79							
80	61,28	51,42	61,06	51,69	60,83	51,95	60,01	52,22	60,38	52,49	60,15	52,75	59,91	53,01	59,69	53,27	80							
81	62,05	52,07	61,82	52,34	61,59	52,61	61,36	52,87	61,13	53,14	60,90	53,41	60,67	53,67	60,43	53,94	81							
82	62,82	52,71	62,58	52,98	62,35	53,25	62,12	53,53	61,89	53,80	61,65	54,07	61,42	54,34	61,18	54,60	82							
83	63,58	53,35	63,35	53,63	63,11	53,90	62,88	54,18	62,64	54,45	62,40	54,73	62,16	55,00	61,92	55,27	83							
84	64,35	54,00	64,11	54,27	63,87	54,55	63,64	54,83	63,40	55,11	63,16	55,38	62,91	55,66	62,67	55,93	84							
85	65,11	54,64	64,87	54,92	64,63	55,20	64,40	55,49	64,15	55,77	63,91	56,04	63,66	56,33	63,42	56,60	85							
86	65,88	55,28	65,64	55,57	65,39	55,85	65,15	56,14	64,91	56,42	64,06	56,70	64,41	56,99	64,16	57,27	86							
87	66,65	56,92	66,40	56,21	66,15	56,50	65,91	56,79	65,06	57,08	65,41	57,36	65,16	57,65	64,91	57,93	87							
88	67,41	56,57	67,16	56,86	66,91	57,13	66,67	57,45	66,42	57,73	66,16	58,02	65,91	58,31	65,65	58,60	88							
89	68,18	57,21	67,93	57,50	67,67	57,80	67,43	58,10	67,17	58,39	66,92	58,68	66,66	58,98	66,40	59,26	89							
90	68,94	57,85	68,69	58,15	68,44	58,45	68,18	58,76	67,92	59,05	67,67	59,34	67,41	59,64	67,13	59,93	90							
91	69,71	58,49	69,45	58,80	69,19	59,10	68,94	59,40	68,68	59,70	68,42	60,00	68,16	60,28	67,89	60,60	91							
92	70,48	59,14	70,22	59,44	69,96	59,75	69,70	60,05	69,43	60,36	69,17	60,66	68,90	60,86	68,60	61,26	92							
93	71,24	59,78	70,98	60,09	70,72	60,40	70,46	60,71	70,19	61,01	69,92	61,32	69,65	61,53	69,38	61,93	93							
94	72,01	60,42	71,74	60,74	71,48	61,05	71,20	61,36	70,94	61,67	70,67	61,98	70,40	62,19	70,13	62,59	94							
95	72,77	61,07	72,51	61,38	72,24	61,70	71,96	62,01	71,78	62,33	71,43	62,64	71,15	62,85	70,80	63,26	95							
96	73,54	61,71	73,27	62,02	73,00	62,35	72,72	62,67	72,45	62,98	72,18	63,30	71,90	63,51	71,62	63,93	96							
97	74,31	62,35	74,03	62,67	73,76	63,00	73,48	63,32	73,20	63,64	72,93	63,96	72,65	64,18	72,37	64,59	97							
98	75,07	63,00	74,80	63,32	74,52	63,65	74,24	63,97	73,96	64,29	73,68	64,61	73,10	64,84	73,11	65,25	98							
99	75,84	63,64	75,56	63,97	75,28	64,29	74,99	64,63	74,72	64,95	74,43	65,27	74,13	65,50	73,85	65,92	99							
100	76,60	64,28	76,32	64,61	76,04	64,95	75,76	65,28	75,47	65,61	75,18	65,94	74,90	66,26	74,61	66,59	100							
101	77,37	64,92	77,09	65,26	76,80	65,59	76,52	65,93	76,23	66,26	75,94	66,59	75,65	66,93	75,35	67,23	101							
102	78,14	65,57	77,85	65,90	77,56	66,24	77,27	66,58	76,98	66,92	76,69	67,25	76,39	67,59	76,10	67,92	102							
103	78,90	66,21	78,61	66,55	78,32	66,89	78,03	67,24	77,74	67,57	77,44	67,91	77,14	68,25	76,84	68,59	103							
104	79,67	66,85	79,38	67,20	79,09	67,54	78,79	67,89	78,49	68,23	78,19	68,57	77,89	68,92	77,59	69,25	104							
105	80,43	67,49	80,14	67,84	79,85	68,19	79,55	68,54	79,25	68,88	78,94	69,23	78,64	69,58	78,33	69,92	105							
106	81,20	68,14	80,90	68,49	80,61	68,84	80,31	69,19	80,00	69,54	79,70	69,89	79,39	70,24	79,08	70,58	106							
107	81,97	68,78	81,06	69,13	81,37	69,49	81,06	69,85	80,76	70,20	80,45	70,55	80,14	70,91	79,83	71,25	107							
108	82,73	69,42	82,43	69,78	82,13	70,14	81,82	70,50	81,51	70,83	81,20	71,21	80,89	71,57	80,57	71,92	108							
109	83,50	70,07	83,19	70,43	82,89	70,79	82,58	71,15	82,66	71,51	81,95	71,87	81,64	72,23	81,32	72,58	109							
110	84,26	70,71	83,96	71,07	83,65	71,44	83,33	71,80	83,08	72,17	82,70	72,53	82,39	72,89	82,07	73,25	110							
111	85,03	71,36	84,72	71,72	84,41	72,09	84,09	72,46	83,77	72,82	83,45	73,19	83,14	73,55	82,81	73,91	111							
112	85,80	71,99	85,48	72,37	85,17	72,74	84,85	73,11	84,53	73,48	84,21	73,83	83,88	74,21	83,56	74,58	112							
113	86,56	72,64	86,24	73,01	85,93	73,39	85,61	73,76	85,28	74,14	84,96	74,51	84,64	74,88	84,31	75,25	113							
114	87,33	73,28	87,01	73,66	86,69	74,04	86,37	74,42	86,04	74,79	85,71	75,17	85,39	75,54	85,05	75,91	114							
115	88,09	73,92	87,78	74,30	87,45	74,68	87,12	75,07	86,79	75,45	86,46	75,88	86,14	76,20	85,80	76,58	115							
116	88,80	74,57	88,53	74,96	88,21	75,33	87,88	75,72	87,55	76,10	87,21	76,48	86,88	76,87	86,54	77,34	116							
117	89,63	75,21	89,30	75,60	88,97	75,98	89,64	76,38	88,30	76,76	87,97	77,14	87,63	77,53	87,29	78,01	117							
118	90,39	75,85	90,06	76,13	89,73	76,63	90,39	77,03	89,06	77,42	88,72	77,80	88,38	78,19	88,04	78,68	118							
119	91,10	76,49	90,82	76,78	90,49	77,28	90,15	77,68	89,81	78,07	89,47	78,46	89,13	78,86	88,78	79,34	119							
120	91,93	77,14	91,59	77,53	91,25	77,93	90,91	78,33	90,56	78,73	90,22	79,12	89,88	79,51	89,53	79,91	120							
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance							
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.									
	50 Deg.								49 Degrees								48 Degrees							

Distance	42 Degrees								43 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
1	0,74	0,67	0,74	0,67	0,74	0,68	0,73	0,68	0,73	0,68	0,73	0,68	0,72	0,69	0,72	0,69	1
2	1,49	1,34	1,48	1,34	1,47	1,35	1,47	1,36	1,46	1,36	1,46	1,37	1,45	1,38	1,44	1,38	2
3	2,23	2,07	2,22	2,02	2,21	2,03	2,20	2,04	2,19	2,05	2,18	2,06	2,18	2,06	2,17	2,07	3
4	2,97	2,68	2,96	2,69	2,95	2,70	2,94	2,71	2,92	2,73	2,93	2,74	2,90	2,75	2,89	2,77	4
5	3,72	3,35	3,70	3,36	3,69	3,38	3,67	3,39	3,66	3,41	3,64	3,43	3,63	3,44	3,61	3,46	5
6	4,46	4,01	4,44	4,03	4,42	4,05	4,41	4,07	4,39	4,09	4,37	4,11	4,35	4,13	4,33	4,15	6
7	5,20	4,68	5,18	4,71	5,16	4,73	5,14	4,75	5,12	4,77	5,10	4,80	5,08	4,82	5,06	4,84	7
8	5,94	5,35	5,92	5,38	5,90	5,40	5,87	5,43	5,85	5,46	5,83	5,48	5,80	5,51	5,78	5,53	8
9	6,69	6,02	6,66	6,05	6,64	6,08	6,61	6,11	6,58	6,14	6,55	6,17	6,53	6,19	6,50	6,22	9
10	7,43	6,69	7,40	6,72	7,37	6,76	7,34	6,79	7,31	6,82	7,28	6,85	7,25	6,88	7,22	6,91	10
11	8,17	7,36	8,14	7,40	8,11	7,43	8,08	7,47	8,04	7,50	8,01	7,54	7,98	7,57	7,95	7,61	11
12	8,92	8,03	8,88	8,07	8,85	8,11	8,81	8,15	8,78	8,18	8,74	8,22	8,70	8,26	8,67	8,30	12
13	9,66	8,70	9,62	8,74	9,58	8,78	9,55	8,82	9,51	8,87	9,47	8,91	9,43	8,95	9,39	8,99	13
14	10,40	9,37	10,36	9,41	10,32	9,46	10,28	9,50	10,24	9,55	10,20	9,59	10,15	9,64	10,11	9,68	14
15	11,15	10,04	11,10	10,08	11,06	10,13	11,01	10,18	10,97	10,23	10,92	10,28	10,88	10,32	10,83	10,37	15
16	11,89	10,71	11,84	10,76	11,79	10,81	11,75	10,86	11,70	10,91	11,65	10,96	11,60	11,01	11,56	11,07	16
17	12,63	11,37	12,58	11,43	12,53	11,49	12,48	11,54	12,43	11,59	12,38	11,65	12,33	11,70	12,28	11,76	17
18	13,38	12,04	13,32	12,10	13,27	12,16	13,22	12,22	13,16	12,28	13,11	12,33	13,05	12,39	13,00	12,45	18
19	14,12	12,71	14,06	12,77	14,01	12,84	13,96	12,90	13,89	12,96	13,84	13,04	13,78	13,08	13,72	13,14	19
20	14,86	13,38	14,80	13,45	14,75	13,51	14,69	13,58	14,63	13,64	14,57	13,70	14,51	13,77	14,45	13,83	20
21	15,61	14,05	15,54	14,12	15,58	14,19	15,42	14,25	15,36	14,32	15,29	14,39	15,23	14,45	15,17	14,52	21
22	16,35	14,72	16,28	14,79	16,22	14,86	16,15	14,93	16,09	15,00	16,02	15,07	15,96	15,14	15,89	15,21	22
23	17,09	15,39	17,02	15,46	16,96	15,54	16,89	15,61	16,82	15,69	16,75	15,76	16,68	15,83	16,61	15,91	23
24	17,83	16,06	17,76	16,13	17,79	16,22	17,62	16,29	17,55	16,37	17,48	16,44	17,41	16,52	17,33	16,00	24
25	18,58	16,73	18,50	16,81	18,43	16,89	18,36	16,97	18,28	17,05	18,21	17,13	18,13	17,21	18,06	17,29	25
26	19,32	17,40	19,24	17,47	19,17	17,57	19,09	17,65	19,01	17,73	18,94	17,81	18,86	17,89	18,77	17,98	26
27	20,06	18,07	19,98	18,15	19,91	18,24	19,82	18,33	19,74	18,41	19,66	18,50	19,58	18,58	19,50	18,67	27
28	20,81	18,73	20,72	18,82	20,64	18,92	20,56	19,01	20,47	19,10	20,39	19,18	20,31	19,27	20,22	19,37	28
29	21,55	19,40	21,46	19,49	21,38	19,60	21,29	19,69	21,21	19,78	21,12	19,87	21,03	19,96	20,94	20,06	29
30	22,29	20,07	22,21	20,17	22,12	20,27	22,03	20,36	21,94	20,46	23,85	20,55	21,76	20,65	21,67	20,74	30
31	23,04	20,74	22,95	20,84	22,85	20,94	22,76	21,04	22,67	21,14	22,58	21,24	22,49	21,34	22,39	21,44	31
32	23,78	21,41	23,69	21,51	23,59	21,61	23,50	21,72	23,40	21,82	23,30	21,92	23,21	22,03	23,11	22,13	32
33	24,52	22,08	24,43	22,19	24,33	22,30	24,23	22,40	24,13	22,51	24,02	22,61	23,94	22,71	23,84	22,82	33
34	25,27	22,75	25,17	22,86	25,07	22,96	24,97	23,08	24,86	23,19	24,75	23,29	24,66	23,40	24,56	23,51	34
35	26,01	23,42	25,91	23,53	25,80	23,64	25,70	23,76	25,60	23,87	25,48	23,98	25,39	24,09	25,28	24,20	35
36	26,75	24,09	26,05	24,20	26,54	24,31	26,43	24,44	26,32	24,55	26,21	24,66	26,11	24,78	26,00	24,90	36
37	27,49	24,76	27,39	24,87	27,28	24,99	27,17	25,19	27,06	25,23	26,94	25,35	26,84	25,47	26,73	25,59	37
38	28,24	25,43	28,13	25,55	28,01	25,67	27,90	25,82	27,79	25,91	27,66	25,93	27,56	26,16	27,45	26,28	38
39	28,98	26,09	28,87	26,22	28,75	26,34	28,64	26,50	28,52	26,61	28,39	26,62	28,29	26,84	28,18	26,97	39
40	29,73	26,76	29,61	26,89	29,49	27,02	29,37	27,15	29,25	27,28	29,13	27,41	29,01	27,53	28,89	27,60	40
41	30,47	27,43	30,35	27,57	30,23	27,70	30,11	27,83	29,98	27,96	29,86	28,09	29,74	28,22	29,62	28,55	41
42	31,21	28,10	31,09	28,24	30,96	28,38	30,84	28,51	30,72	28,64	30,59	28,78	30,46	28,91	30,34	29,04	42
43	31,95	28,77	31,83	28,91	31,69	29,05	31,57	29,19	31,45	29,33	31,32	29,46	31,19	29,60	31,06	29,74	43
44	32,70	29,44	32,57	29,58	32,43	29,73	32,31	29,87	32,18	30,01	32,05	30,15	31,91	30,29	31,78	30,43	44
45	33,44	30,10	33,31	30,25	33,17	30,40	33,04	30,55	32,91	30,69	32,77	30,83	32,64	30,97	32,50	31,12	45
46	34,18	30,77	34,05	30,93	33,90	31,08	33,78	31,33	33,64	31,37	33,50	31,52	33,36	31,66	33,23	31,82	46
47	34,93	31,44	34,79	31,60	34,64	31,76	34,51	31,90	34,37	32,05	34,23	32,20	34,09	32,35	33,95	32,51	47
48	35,67	32,11	35,53	32,27	35,38	32,43	35,24	32,58	35,10	32,74	34,96	32,89	34,82	33,94	34,67	33,20	48
49	36,41	32,78	36,27	32,94	36,11	33,11	35,98	33,26	35,83	33,42	35,69	33,57	35,54	33,73	35,39	33,90	49
50	37,16	33,46	37,01	33,62	36,86	33,78	36,72	33,94	36,57	34,10	36,42	34,26	36,27	34,41	36,12	34,58	50
51	37,90	34,13	37,75	34,29	37,60	34,46	3										

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Distance	42 Degrees								43 Degrees								Distance
	0 Min.		15 Min.		30 Min.		45 Min.		0 Min.		15 Min.		30 Min.		45 Min.		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
61	45,33	40,82	45,15	41,01	44,97	41,21	44,79	41,44	44,61	41,60	44,43	41,80	44,25	41,99	44,06	42,18	61
62	46,07	41,49	45,89	41,69	45,71	41,89	45,53	42,09	45,34	42,28	45,16	42,48	44,97	42,68	44,79	42,87	62
63	46,82	42,15	46,63	42,36	46,45	42,50	46,26	42,76	46,07	42,97	45,89	43,17	45,70	43,36	45,51	43,57	63
64	47,56	42,82	47,37	43,03	47,18	43,23	46,99	43,44	46,80	43,6	46,61	43,8	46,42	44,05	46,23	44,26	64
65	48,30	43,49	48,11	43,70	47,92	43,91	47,73	44,12	47,54	44,33	47,34	44,54	47,15	44,74	46,95	44,95	65
66	49,05	44,16	48,85	44,37	48,66	44,58	48,46	44,80	48,27	45,01	48,07	45,22	47,87	45,43	47,67	45,64	66
67	49,79	44,83	49,59	45,05	49,40	45,26	49,20	45,48	49,00	45,69	48,80	45,91	48,60	46,12	48,40	46,33	67
68	50,53	45,50	50,33	45,72	50,13	45,93	49,93	46,16	49,73	46,38	49,53	46,59	49,32	46,80	49,12	47,03	68
69	51,27	46,17	51,07	46,40	50,87	46,61	50,66	46,84	50,46	47,06	50,25	47,28	50,05	47,49	49,84	47,72	69
70	52,02	46,84	51,81	47,07	51,61	47,29	51,40	47,52	51,19	47,74	50,99	47,96	50,78	48,18	50,56	48,41	70
71	52,76	47,51	52,55	47,74	52,35	47,97	52,14	48,19	51,93	48,42	51,71	48,65	51,50	48,87	51,29	49,10	71
72	53,51	48,18	53,29	48,41	53,08	48,64	52,87	48,87	52,66	49,10	52,44	49,33	52,23	49,56	52,01	49,79	72
73	54,25	48,85	54,03	49,08	53,82	49,32	53,60	49,55	53,39	49,79	53,17	50,02	52,95	50,25	52,73	50,48	73
74	54,99	49,51	54,77	49,75	54,56	49,99	54,34	50,23	54,42	50,47	53,90	50,70	53,68	50,94	53,45	51,17	74
75	55,73	50,18	55,51	50,43	55,29	50,67	55,07	50,91	54,85	51,15	54,63	51,39	54,40	51,62	54,17	51,87	75
76	56,48	50,85	56,25	51,10	56,03	51,35	55,81	51,59	55,58	51,83	55,35	52,07	55,13	52,31	54,90	52,56	76
77	57,22	51,52	56,99	51,77	56,77	52,02	56,54	52,27	56,31	52,51	56,08	52,76	55,85	53,00	55,62	53,25	77
78	57,96	52,19	57,73	52,44	57,51	52,70	57,27	52,95	57,04	53,20	56,81	53,44	56,58	53,69	56,34	33,94	78
79	58,71	52,86	58,47	53,11	58,24	53,37	58,01	53,63	57,77	53,88	57,54	54,13	57,30	54,38	57,06	54,63	79
80	59,45	53,53	59,22	53,79	58,98	54,05	58,75	54,30	58,51	54,56	58,27	54,81	58,03	55,07	57,79	55,32	80
81	60,19	54,20	59,96	54,46	59,72	54,72	59,48	54,98	59,24	55,24	59,00	55,50	58,75	55,76	58,51	56,01	81
82	60,94	54,87	60,70	55,13	60,46	55,40	60,21	55,66	59,97	55,92	59,73	56,18	59,48	56,44	59,23	56,70	82
83	61,68	55,54	61,44	55,81	61,19	56,07	60,95	56,34	60,70	56,61	60,45	56,87	60,20	57,13	59,95	57,40	83
84	62,42	56,21	62,18	56,48	61,93	56,75	61,68	57,02	61,43	57,29	61,18	57,55	60,92	57,82	60,68	58,08	84
85	63,17	56,87	62,92	57,15	62,67	57,43	62,42	57,70	62,16	57,97	61,91	58,23	61,65	58,51	61,40	58,78	85
86	63,91	57,51	63,66	57,82	63,40	58,10	63,15	58,38	62,89	58,65	62,64	58,92	62,38	59,20	62,12	59,47	86
87	64,65	58,21	64,40	58,49	64,14	58,78	63,88	59,06	63,62	59,33	63,37	59,61	63,10	59,88	62,84	60,16	87
88	65,39	58,88	65,14	59,17	64,88	59,46	64,62	59,74	64,36	60,02	64,09	60,29	63,83	60,57	63,56	60,86	88
89	66,14	59,55	65,88	59,84	65,61	60,13	65,35	60,41	65,09	60,70	64,82	60,98	64,55	61,26	64,29	61,55	89
90	66,88	60,22	66,62	60,51	66,35	60,80	66,09	61,09	65,82	61,38	65,55	61,67	65,28	61,95	65,01	62,24	90
91	67,63	60,89	67,36	61,18	67,09	61,48	66,82	61,77	66,55	62,06	66,28	62,35	66,01	62,64	65,73	62,93	91
92	68,37	61,56	68,10	61,86	67,83	62,15	67,56	62,45	67,28	62,74	67,01	63,04	66,73	63,33	66,46	63,62	92
93	69,11	62,23	68,84	62,53	68,57	62,83	68,29	63,13	68,01	63,43	67,74	63,72	67,46	64,02	67,18	64,31	93
94	69,85	62,90	69,58	63,20	69,30	63,51	69,02	63,81	68,75	64,11	68,46	64,41	68,18	64,70	67,90	65,00	94
95	70,60	63,57	70,32	63,87	70,04	64,18	69,76	64,49	69,48	64,79	69,19	65,09	68,91	65,39	68,62	65,70	95
96	71,34	64,24	71,06	64,54	70,78	64,86	70,49	65,17	70,21	65,47	69,92	65,78	69,63	66,08	69,34	66,39	96
97	72,08	64,9	71,80	65,22	71,51	65,53	71,23	65,84	70,94	66,15	70,6	66,46	70,36	66,77	70,07	67,08	97
98	72,83	65,57	72,54	65,89	72,25	66,21	71,96	66,52	71,67	66,84	71,38	67,15	71,08	67,46	70,79	67,77	98
99	73,57	66,24	73,28	66,56	72,99	66,89	72,69	67,20	72,40	67,52	72,10	67,83	71,81	68,14	71,51	68,46	99
100	74,31	66,91	74,02	67,24	73,73	67,56	73,43	67,88	73,13	68,20	72,84	68,52	72,54	68,83	72,24	69,15	100
101	75,06	67,58	74,76	67,91	74,46	68,23	74,17	68,56	73,87	68,88	73,56	69,20	73,26	69,52	72,96	69,84	101
102	75,80	68,25	75,50	68,58	75,20	68,90	74,90	69,24	74,60	69,56	74,29	69,89	73,99	70,21	73,68	70,53	102
103	76,54	68,92	76,24	69,25	75,94	69,58	75,63	69,92	75,33	70,25	75,02	70,57	74,71	70,90	74,40	71,23	103
104	77,29	69,59	76,98	69,92	76,68	70,25	76,37	70,60	76,06	70,93	75,75	71,26	75,44	71,57	75,12	71,92	104
105	78,03	70,26	77,72	70,60	77,41	70,93	77,10	71,27	76,79	71,61	76,48	71,94	76,16	72,25	75,84	72,61	105
106	78,77	70,93	78,46	71,27	78,15	71,60	77,84	71,95	77,52	72,39	77,20	72,63	76,89	72,94	76,57	73,30	106
107	79,51	71,5	79,20	71,94	78,89	72,28	78,57	72,63	78,25	73,07	77,93	73,31	77,61	73,63	77,29	73,99	107
108	80,26	72,26	79,94	72,62	79,63	72,96	79,30	73,31	78,98	73,76	78,68	74,00	78,34	74,32	78,01	74,69	108
109	81,00	72,93	80,68	73,29	80,36	73,63	80,04	73,99	79,71	74,14	79,41	74,68	79,06	75,01	78,73	75,38	109
110	81,74	73,60	81,42	73,96	81,10	74,31	80,77	74,67	80,45	75,02	80,12	75,37	79,79	75,71	79,10	76,07	110
111	82,49	74,27	82,16	74,63	81,84	74,99	81,51	75,35	81,18	75,70	80,85	76,05	80,82	76,41	80,18	76,75	111
112	83,23	74,94	82,90	75,30	82,57	75,67	82,24	76,03	81,91	76,38	81,58	76,74	81,24	77,09	80,90	77,46	112
113	83,97	75,01	83,64	75,98	83,31	76,34	82,98	76,70	82,04	77,07	82,30	77,42	81,97	77,78	81,63	78,14	113
114	84,72	76,28	84,38	76,65	84,05	77,02	83,71	77,38	83,37	77,75	83,03	78,11	82,69	78,47	82,35	78,83	114
115	85,46	76,95	85,12	77,32	84,79	77,69	84,44	78,06	84,10	78,43	83,76	78,79	83,42	79,10	83,07	79,53	115
116	86,20	77,62	85,86	77,99	85,52	78,37	85,18	78,74	84,83	79,11	84,49	79,48	84,13	79,85	83,79	80,22	116
117	86,95	78,28	86,60	78,66	86,26	79,07	85,91	79,42	85,57	79,79	85,22	80,17	84,86	80,54	84,51	80,92	117
118	87,69	78,95	87,34	79,34	86,99	79,74	86,65	80,10	86,30	80,48	85,95	80,85	85,58	81,22	85,24	81,60	118
119	88,43	79,63	88,08	80,01	87,73	80,42	87,38	80,78	87,03	81,16	86,67	81,54	86,31	81,91	85,96	82,29	119
120	89,18	80,30	88,83	80,68	88,47	81,07	88,12	81,46	87,76	81,84	87,40	82,22	87,04	82,60	86,68	82,98	120
Distance	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance
	0 Min.		45 Min.		30 Min.		15 Min.		0 Min.		45 Min.		30 Min.		15 Min.		
	48 Deg.				47 Degrees				46 Degrees								

TRAVERSE TABLE, 712.

Distance	44 Degrees						45 Deg.		44 Degrees						45 Deg.		Distance																
	0 Min.		20 Min.		40 Min.		0 Min.		0 Min.		20 Min.		40 Min.		0 Min.																		
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.																	
1	0,72	0,69	0,72	0,70	0,71	0,70	0,71	0,71	43,88	42,37	43,63	42,63	43,38	42,88	43,13	43,13	61																
2	1,44	1,39	1,43	1,4	1,42	1,41	1,41	1,41	44,60	43,09	44,35	43,33	44,09	43,58	43,84	43,84	62																
3	2,16	2,08	2,15	2,10	2,13	2,11	2,12	2,12	45,32	43,86	45,06	44,03	44,81	44,29	44,55	44,55	63																
4	2,88	2,78	2,86	2,79	2,84	2,81	2,83	2,83	46,04	44,46	45,78	44,73	45,52	44,99	45,25	45,25	64																
5	3,60	3,47	3,58	3,49	3,56	3,51	3,53	3,53	46,75	45,15	46,49	45,42	46,23	45,69	45,96	45,96	65																
6	4,32	4,17	4,29	4,19	4,27	4,22	4,24	4,24	47,47	45,85	47,21	46,12	46,94	46,40	46,67	46,67	66																
7	5,03	4,86	5,01	4,89	4,98	4,92	4,95	4,95	48,19	46,54	47,92	46,82	47,55	47,10	47,38	47,38	67																
8	5,75	5,56	5,72	5,59	5,69	5,62	5,66	5,66	48,91	47,24	48,64	47,52	48,36	47,80	48,08	48,08	68																
9	6,47	6,25	6,44	6,29	6,40	6,33	6,36	6,36	49,63	48,93	49,35	48,22	49,08	48,50	48,79	48,79	69																
10	7,19	6,95	7,15	6,99	7,11	7,03	7,07	7,07	50,35	48,63	50,07	48,92	49,78	49,21	49,50	49,50	70																
11	7,91	7,64	7,87	7,69	7,82	7,73	7,78	7,78	51,07	49,32	50,78	49,62	50,43	49,91	50,20	50,20	71																
12	8,63	8,34	8,58	8,39	8,53	8,44	8,49	8,49	51,79	50,02	51,50	50,32	51,21	50,61	50,91	50,91	72																
13	9,35	9,03	9,30	9,08	9,25	9,14	9,19	9,19	52,81	50,71	52,21	51,01	51,91	51,32	51,62	51,62	73																
14	10,07	9,73	10,01	9,78	9,96	9,84	9,90	9,90	53,53	51,41	52,93	51,71	52,63	52,02	52,33	52,33	74																
15	10,79	10,42	10,73	10,48	10,67	10,54	10,61	10,61	54,25	52,10	53,64	52,41	53,34	52,72	53,03	53,03	75																
16	11,51	11,12	11,44	11,18	11,38	11,25	11,31	11,31	54,97	52,80	54,36	53,11	54,05	53,42	53,74	53,74	76																
17	12,23	11,81	12,16	12,88	12,09	11,95	12,02	12,02	55,69	53,49	55,07	53,81	54,76	54,13	54,45	54,45	77																
18	12,94	12,51	12,87	12,57	12,70	12,65	12,73	12,73	56,41	54,29	55,79	54,51	55,47	54,83	55,15	55,15	78																
19	13,65	13,20	13,59	13,27	13,41	13,36	13,43	13,43	57,12	54,98	56,50	55,21	56,18	55,53	55,86	55,86	79																
20	14,39	13,89	14,31	13,98	14,22	14,06	14,14	14,14	57,55	55,57	57,22	55,91	56,90	56,24	56,57	56,57	80																
21	15,11	14,59	15,02	14,68	14,93	14,76	14,85	14,85	58,27	56,27	57,94	56,60	57,61	56,94	57,28	57,28	81																
22	15,82	15,28	15,74	15,37	15,65	15,46	15,56	15,56	58,98	56,96	58,65	57,30	58,32	57,64	57,98	57,98	82																
23	16,54	15,98	16,45	16,07	16,36	16,17	16,26	16,26	59,70	57,66	59,37	58,00	59,03	58,35	58,69	58,69	83																
24	17,26	16,67	17,17	16,77	17,07	16,87	16,97	16,97	60,42	58,35	60,08	58,70	59,74	59,05	59,40	59,40	84																
25	17,98	17,37	17,88	17,47	17,78	17,57	17,68	17,68	61,14	59,05	60,80	59,40	60,45	59,75	60,10	60,10	85																
26	18,70	18,0	18,60	18,17	18,49	18,28	18,38	18,38	61,86	59,74	61,51	60,10	61,16	60,45	60,81	60,81	86																
27	19,42	18,76	19,31	18,87	19,20	18,98	19,09	19,09	62,58	60,44	62,23	60,80	61,87	61,16	61,52	61,52	87																
28	20,14	19,45	20,03	19,57	19,91	19,68	19,80	19,80	63,30	61,13	62,94	61,50	62,58	61,86	62,22	62,22	88																
29	20,86	20,15	20,74	20,27	20,62	20,39	20,51	20,51	64,02	61,83	63,66	62,20	63,30	62,56	62,93	62,93	89																
30	21,58	20,84	21,46	20,96	21,34	21,09	21,21	21,21	64,74	62,52	64,38	62,89	64,01	63,27	63,64	63,64	90																
31	22,30	21,53	22,17	21,06	22,0	21,79	21,92	21,92	65,46	63,21	65,09	63,59	64,72	63,97	64,35	64,35	91																
32	23,02	22,25	22,89	21,76	22,76	22,49	22,63	22,63	66,18	64,01	65,81	64,29	65,43	64,67	65,05	65,05	92																
33	23,74	22,92	23,60	22,46	23,47	23,20	23,33	23,33	66,90	64,70	66,52	64,99	66,14	65,37	65,76	65,76	93																
34	24,46	23,62	24,32	23,16	24,18	23,90	24,04	24,04	67,62	65,40	67,24	65,68	66,85	66,08	66,47	66,47	94																
35	25,17	24,31	25,03	23,86	24,89	24,60	24,75	24,75	68,34	66,09	67,95	66,39	67,56	66,78	67,17	67,17	95																
36	25,89	25,1	25,75	24,56	25,60	25,31	25,46	25,46	69,05	66,79	68,67	67,09	68,27	67,48	67,88	67,88	96																
37	26,61	25,71	26,46	25,26	26,31	26,01	26,16	26,16	69,77	67,48	69,38	67,79	68,99	68,19	68,59	68,59	97																
38	27,33	26,41	27,18	25,91	27,02	26,71	26,87	26,87	70,49	68,18	70,10	68,49	69,70	68,89	69,30	69,30	98																
39	28,05	27,10	27,89	26,66	27,73	27,42	27,58	27,58	71,21	68,87	70,81	69,19	70,41	69,59	70,00	70,00	99																
40	28,77	27,79	28,61	27,95	28,45	28,12	28,28	28,28	71,93	69,47	71,53	69,88	71,12	70,30	70,71	70,71	100																
41	29,49	28,48	29,33	28,65	29,16	28,82	28,99	28,99	72,65	70,16	72,24	70,58	71,83	71,00	71,42	71,42	101																
42	30,21	29,1	30,04	29,35	29,87	29,52	29,70	29,70	73,37	70,86	72,96	71,28	72,54	71,70	72,12	72,12	102																
43	30,93	29,87	30,76	30,05	30,58	30,23	30,41	30,41	74,09	71,55	73,67	71,98	73,25	72,40	72,83	72,83	103																
44	31,65	30,57	31,47	30,75	31,29	30,93	31,11	31,11	74,81	72,25	74,39	72,68	73,96	73,11	73,54	73,54	104																
45	32,37	31,26	32,19	31,45	32,00	31,63	31,82	31,82	75,53	72,94	75,10	73,38	74,68	73,81	74,25	74,25	105																
46	33,09	31,96	32,90	32,14	32,71	32,34	32,53	32,53	76,25	73,64	75,82	74,08	75,39	74,51	74,95	74,95	106																
47	33,81	32,6	33,62	32,84	33,43	33,04	33,23	33,23	76,97	74,33	76,53	74,78	76,10	75,22	75,66	75,66	107																
48	34,53	33,35	34,33	33,54	34,14	33,74	33,94	33,94	77,69	75,03	77,25	75,47	76,81	75,92	76,37	76,37	108																
49	35,24	34,04	35,05	34,24	34,85	34,44	34,65	34,65	78,40	75,72	77,96	76,17	77,52	76,62	77,07	77,07	109																
50	35,97	34,73	35,76	34,94	35,56	35,15	35,35	35,35	79,13	76,41	78,68	76,87	78,23	77,33	77,78	77,78	110																
51	36,69	35,43	36,48	35,64	36,27	35,85	36,06	36,06	79,85	77,11	79,40	77,57	78,95	78,04	78,49	78,49	111																
52	37,40	36,12	37,19	36,34	36,98	36,55	36,77	36,77	80,56	77,80	80,11	78,27	79,65	78,74	79,20	79,20	112																
53	38,12	36,82	37,91	37,04	37,69	37,26	37,47	37,47	81,28	78,50	80,83	78,97	80,37	79,43	79,90	79,90	113																
54	38,84	37,51	38,62	37,74	38,40	37,96	38,18	38,18	82,00	79,19	81,54	79,67	81,08	80,1	80,61	80,61	114																
55	39,56	38,21	39,34	38,44	39,12	38,66	38,89	38,89	82,72	79,89	82,26	80,37	81,79	80,85	81,32	81,32	115																
56	40,28	38,90	40,05	39,14	39,82	39,37	39,59	39,59	83,44	80,58	82,97	81,06	82,50	81,55	82,02	82,02	116																
57	41,01	39,60	40,77	39,84	40,54	40,07	40,30	40,30	84,16	81,28	83,69	81,76	83,21	82,26	82,73	82,73	117																
58	41,72	40,29	41,48	40,53	41,25	40,77	41,01	41,01	84,88	81,97	84,40	82,46	83,92	82,96	83,44	83,44	118																
59	42,44	40,99	41,20	41,23	41,96	41,48	41,72	41,72	85,60	82,67	85,12	83,16	84,68	83,66	84,14	84,14	119																
60	43,16	41,88	42,92	41,93	42,67	42,18	42,43	42,43	86,32	83,36	85,83	83,86	84,34	84,35	84,85	84,85	120																
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Distance																
	0 Min.	40 Min.	20 Min.	0 Min.	0 Min.	40 Min.	20 Min.	0 Min.	0 Min.	40 Min.	20 Min.	0 Min.	0 Min.	40 Min.	20 Min.	0 Min.	Distance																
	45 Degrees																46 Deg.	45 Degrees															

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